PRACTICAL TANNING

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A HANDBOOK OF MODERN PRACTICE AND PROCESSES AS APPLIED IN THE MANUFACTURE OF LEATHER AND ALLIED PRODUCTS

BY

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Partly Based on the Third Edition of "Practical Tanning," by Louis A. Flemming

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# PREFACE

In presenting this book on leather manufacture I have endeavored to arrange the text with as little repetition as possible. The various processes have been taken up in the order of their sequence, and where the same procedure is carried out for various classes I have attempted to point out the most satisfactory method for each classification. For example, the processes of depilation are included in one chapter, and the various ways of accomplishing this end are thoroughly discussed.



Being intended primarily for those interested in the actual production of leather, this book deals with the subject from the practical rather than from the theoretical standpoint, and it is hoped that by following the instructions given the tanner may find suggestions which will serve to improve his product or assist him in producing new varieties of leather. Where it has been found necessary to discuss the underlying scientific principles, these are stated in as simple a manner as possible.

A chapter on analytical methods has been included, not only for the benefit of the works chemist and student, but also in order that the practical man in the plant may be able to obtain some idea of the methods necessary for the chemical control of the material he handles.

In addition to the common standard methods of tanning, a number of unusual processes are given, as well as descriptions of some of the more recent products which have been introduced as a substitute for the ordinary materials employed in leather manufacture.

Much of the matter herein has been taken from the previous volumes of "Practical Tanning," by Louis A. Flemming, and, in addition, many processes have been included as a result of my personal experience. In many instances also, material

has been drawn from trade papers and technical journals, as well as from notes furnished by men who are well known in the industry. In presenting this material it is desired to give full credit to these sources of information, which will be found in the text.

In a book of this character, covering so wide a range of methods, there are always points where a difference of opinion may exist, and it is hoped, therefore, that wherever this occurs, the reader will feel at liberty to communicate with me, as any constructive criticism will always be greatly appreciated.

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# INTRODUCTION

In presenting any book on a special subject it is customary to commence with the history of that subject, and by gradual stages bring it down to the present time. In attempting to do this, the author encountered so many difficulties and so many unauthentic, conflicting records that he gave it up as being too uncertain. If, however, any dependence can be placed upon the records of Scripture, we must conclude that the manufacture of leather is the oldest of the industries, for in Genesis III, 21, we read, "Unto Adam also and to his wife did the Lord God make coats of skins and clothed them."

It is interesting to know that the first method for preserving hide and skin in a more or less pliable and imputrescible condition probably consisted in treating the pelt with the grease and brains of the animal itself, which were worked in by a process of pounding and stretching. Following this primitive method came the smoke treatment, then the application of salts containing alum. The dyeing of this leather no doubt led to the discovery of a few vegetable tanning materials. It remained, however, for the last fifty years to see more done for the advancement of the industry than ever before, and in this wonderful development America has played no small part.

# PRACTICAL TANNING

## CHAPTER I

### HIDES AND SKINS

THE hides and skins used in the manufacture of leather are generally obtained from animals killed for food. The coverings of large animals are classified as hides, whereas those of small animals are known as skins. The production of hides and skins in the United States during 1920 amounted to 894,000,000 lb., green basis, when 1 lb. of dry hide equals 2 lb. of green hide. Hides and skins soon putrefy if allowed to remain in a moist condition, so it becomes necessary to treat them in such a manner that they may be kept undamaged until ready for the tanning processes. This operation, known as curing, may be done in several ways, each one being more or less peculiar to the locality from which the hides are shipped. The cure has a decided influence upon the hide, and largely determines the character of the leather.

**Classification of pelts.**—The pelts of animals come to the tanner in four conditions: (1) *green* (fresh from the animal); (2) *green-salted* (where the salt has been rubbed on the flesh side); (3) *dry-salted* (rubbed with salt and dried); and (4) *dried* (usually stretched on boards in the sun). The pelts so received are divided according to size into three general classes, namely: *hides, kips,* and *skins.* Hides comprise pelts from large and fully grown animals such as the cow, horse, camel and walrus. These give thick, heavy leather for shoe soles, machinery belting, harness, and other purposes where stiffness and strength, combined with wearing qualities, are necessary. They are also cut into splits for use as shoe uppers, and bag, case, strap, automobile, carriage, furniture, and upholstering leathers. Kips are the skins of undersized animals of the above species. Skins are obtained from small animals such as calves, sheep, and goats. Kips and skins yield a lighter leather than hides, which is suitable for a great variety

of purposes such as uppers for shoes, pocketbooks, bookbinding, gloves, and fancy leather. Pelts vary in thickness and texture in different parts, being thicker on the neck and butt than on the flank and belly. Pelts of the same species vary greatly according to the climatic conditions under which the animals are raised, also their breeding and feed. They often show injuries like cuts, brand-marks, grub-holes, and sores caused by the bot-fly or warble. Diseased hides are sometimes found, and are a source of great danger to the tanner on account of the contagious nature of some of the diseases, especially anthrax.

**Dry or flint hides.**—The simplest form of cure consists in drying the hides in the open where they are exposed to the action of both sun and wind, a method commonly adopted in most tropical countries. Although curing by this method has the advantage of simplicity, it has disadvantages owing to the condition of the hide substance. Too rapid drying results in the contraction and hardening of the surface, and the moisture, not being removed from the middle section, gives rise to bacterial action deleterious to the hide substance. As the damage thus caused can only be detected in the beam-house, it is apparent that the practice should be discouraged. The temperature at which hides are dried is of great importance. The best conditions are a comparatively low temperature and good circulation of air. The higher the temperature, the harder the stock and the slower it will wet back in the soaks.

**Dry-salted hides.**—These differ from flint hides in that a coating of salt has been applied to the flesh side, and, after remaining in packs for some time, they are spread out and allowed to dry in the sun. Dry-salted hides have the advantage over dry hides in that they do not contract during the drying, and are much more readily softened in the soaks.

**Green-salted hides.**—The stock coming to the tanner in this condition has been salted on the flesh with common salt and placed in piles to cure. The hides are piled-down in such a manner that the slope is toward the center. In this way the brine formed is retained and the cure materially aided. The

time necessary for a thorough cure is at least thirty days. The hides are taken-up, and, after the salt has been partly removed from them, they are folded into a bundle for shipment.

**Salt stains.**—In salting hides it is sometimes found that iron, in the form of ferric chloride, is present. This iron becomes deposited in the hide, and shows up during the tanning as black spots known as salt stains. Clots of blood or flesh are also likely to produce the same result.

**Packer hides.**—The slaughtering of cattle on a large scale by the great packing-houses of the United States has resulted in a process so efficient that these hides are obtained in nearly as perfect a condition as their nature will permit. Thus the term "packer hide" has come to mean the best hide that can be bought. Skilled labor and attention to details have reduced the possible damage to a minimum.

**Stuck-throats.**—As the cattle arrive at the packing-house they are allowed to rest and cool off. The killing beds are usually arranged on the top floor of the building, and the cattle are driven up through runways or elevators. Two animals go into each knocking pen, there usually being half as many pens as skinning beds. A "knocker" uses a light sledge hammer, and strikes the animal a heavy blow on the forehead between the eyes; if the animal does not drop immediately, a second blow is given. The skull is broken by this heavy blow and the animal becomes unconscious. The gate is now lifted, and by mechanical means the floor of the pen is raised to a sharp angle causing the carcass to slide to the sticking bed. The "sticker" inserts his knife vertically through the neck in such a way as not to tear the pattern of the hide, and when the knife has been entered sufficiently deep, it is turned crosswise to sever the jugular vein. The animal is now shackled by passing a chain around both hind legs, and the body raised from the floor, head down, in order to drain off the blood.

**Cut-throats.**—When animals are killed "kosher," according to the Rabbinical law, the steer is not knocked senseless, but is shackled by the hind legs and raised to such a position that the head just rests on the floor. By means of a muzzle

the head is turned back and the throat washed to remove grit. The Rabbi blesses the animal and with a long knife makes one downward cut back of the jaw, almost severing the head from the spinal column.

**Flaying.**—Whether the animal is a stuck-throat or cut-throat, the operation of flaying is similar in each case. In the

Figure 1.—Skinning the head and cheek. The knife should pass along the hide, starting at the base of the right horn and extending across to the left horn, and then down through the left nostril.

large packing-houses, skinning is done by several men, each performing a specific part of the operation. The "header" sticks his knife in at the top of the head and makes a cut across the left side of the animal's face, continuing downward along the left side through the nostril. The cheeks are skinned out (figure 1), and the under side opened from the sticking cut through the center of the lower lip. This method leaves the pate on the right side of the hide, and allows it to lie flat when placed in the pack. The carcass is next lowered to the

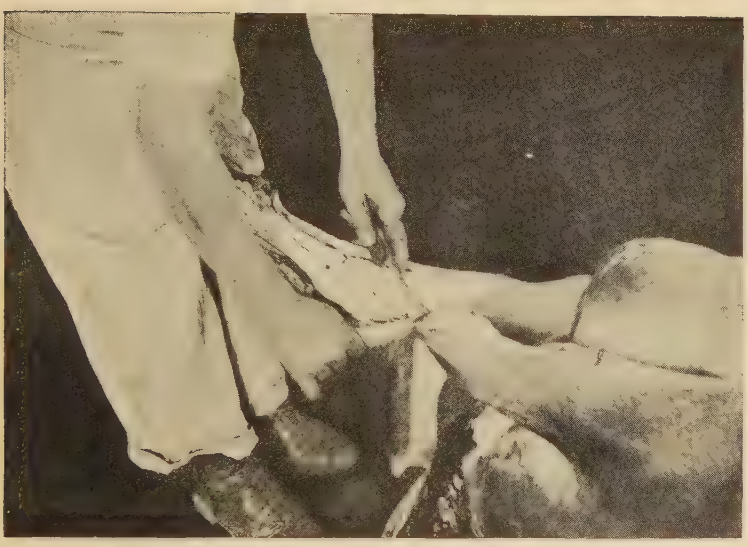

Figure 2.—Skinning the forelegs.

floor where it is laid on the back and held in position by a pritch pole. The claws and feet are removed by the "legger" (figure 2) and the sweetbreads are taken out. In skinning the front legs the cut is upward on the right side and toward the center of the knee. The same holds good of the hind legs,

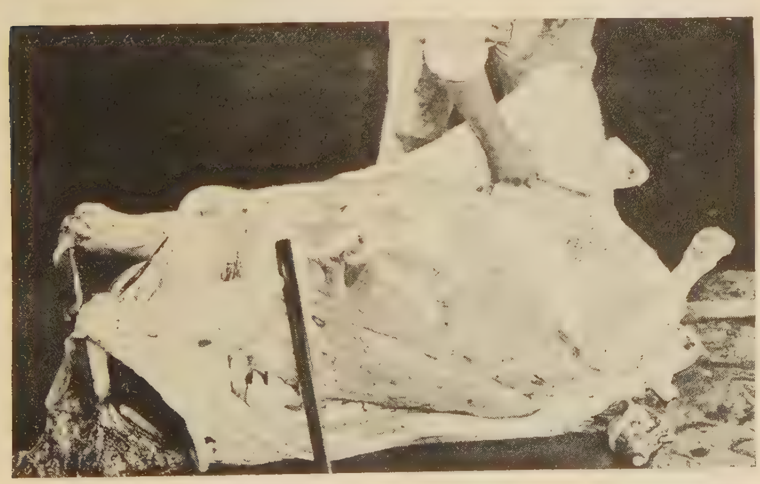

Figure 3.—Skinning the side.

Figure 4.—Skinning the hind legs to make a uniform pattern.

Figure 5.—Skinning the buttocks.

Figure 6.—Skinning the rump.

Figure 7.—Skinning the back.

Figure 8.—Beating the fell over the rump and round.

Figure 9.—Skinning the neck.

except that the cut runs toward the center. The "ripper-open" next follows, opening the steer along the belly (figure 3) from the sticking cut to the tail. The "floorsman" or "sider" now removes the hide from the belly (figure 4) and cuts along the brisket and back to the inside of the hind leg (figure 5) close to the tail. After cutting down the side of the animal he makes the cut at the brisket and foreleg to joint, and, on the

**Figure 10.—Dotted lines show ripping-open cuts necessary to produce a hide of good pattern.**

hind leg (figure 6), he connects with the hind-legger cut. The hide is now carefully removed from the belly and down the sides. The body is then lifted until only the forward quarter remains on the floor, and the "tail-puller" pulls the hide off the tail. The "rumper" (figure 7) cuts the hide away from the base of the tail and rump. The body is again raised, and the "fell cutter" removes the hide from the hind legs and "round." The fell puller takes the hind shanks and pulls, while the "fell beater" (figure 8) pounds away the hide by means of the back

edge of cleavers. The "backer" (figure 9) finishes the flaying by removing the hide from the shoulders. Figures 10 and 11 show cuts required during skinning, while figure 12 shows a hide of good pattern.

**Curing.**—As the hide drops from the carcass it is spread on the floor and inspected for cuts, scores, grubs, and other imperfections. It is then thrown into a chute leading to the

**Figure 11.—Dotted lines indicate proper cuts in skinning the head.**



hide cellar. Here the hides are assorted into different grades, classes and weights, each grade being assembled in its respective pack. The workmen in the hide cellar are usually about two hours behind the killing gang, so that the animal heat may be out of the hides before salting. As the cellar gang receive the hides, they split the ears and then pile them down flat with flesh side up. Over each hide is sprinkled about 40 pounds of rock salt, and the outside hides in the pack are turned over so as to retain the pickle in the stock and hold the pile in

shape. The piles are low and flat to prevent drying out. After the back edge and corners are put in, the sides are built up. When the back and sides have been made, the spreads are put in. This is done in such a manner that the heads come into the center of the pack. As the spreads are placed in, the front is built up. Hides packed in the proper way will keep for one or two years, but in practice they are never left for this length

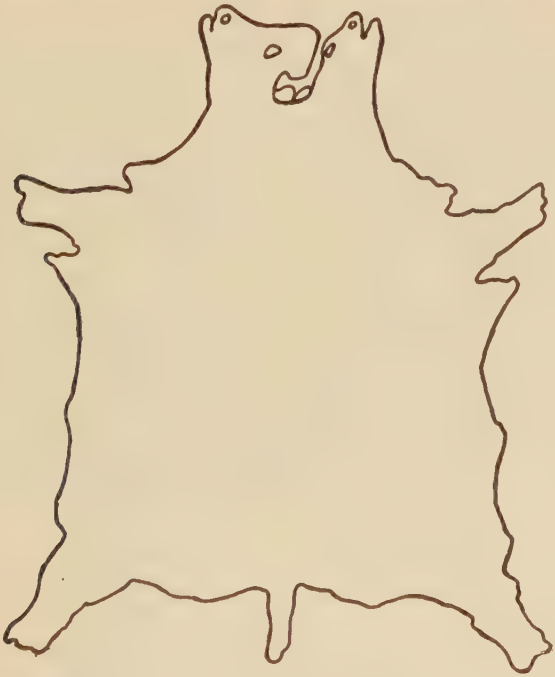

**Figure 12.—A hide of good pattern and trim.**

of time, thirty days being the usual period. The danger of standing too long is indicated by salt stains, but these may be prevented by adding "cyco" powder to the salt. This powder consists essentially of sodium bisulphite, and is sold under the above trade name.

In putting down hides, the work is done by a gang consisting of two spreaders, one salt thrower, and a salt trucker, who should handle about 40 hides an hour. To obtain the best results, the cellars should be kept at as even a temperature as

possible, which should not vary greatly from 65 degrees Fahrenheit.

**Taking-up hides.**—In taking-up a pack of hides, the representatives of buyer and seller are present. As the hides come

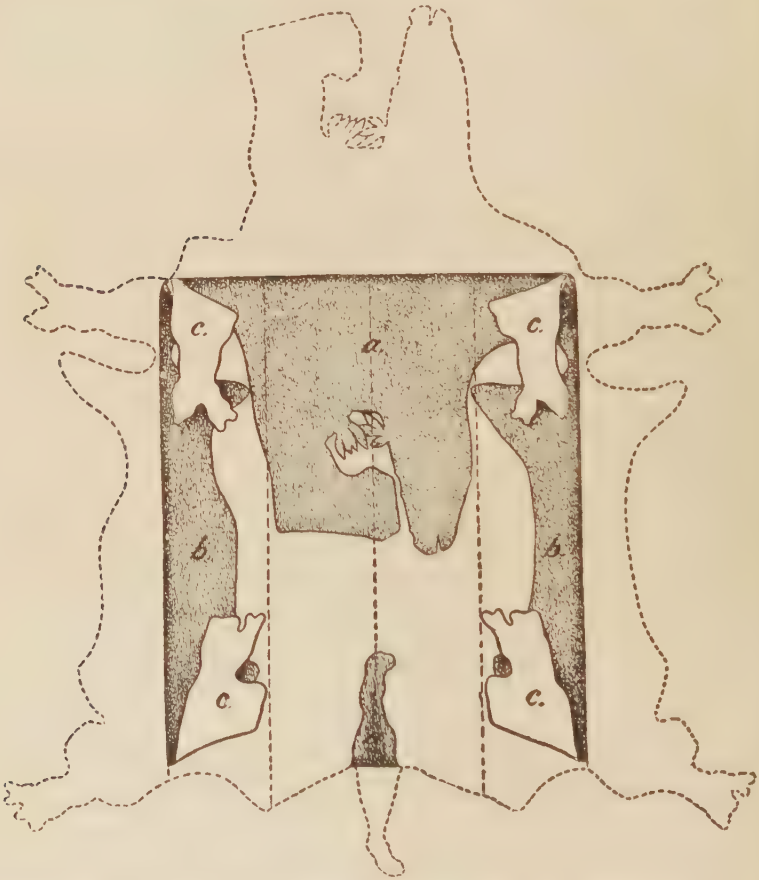


Figure 13.—How to fold a hide: (a) first step; (b) second step; (c) third step. The shading represents the hair side.

from the pack they are shaken and drawn over a "heaver" (a kind of horse) to remove excess salt. They are then spread on the floor, hair side up, and inspected for hairslips, manure, and brands. They are next turned flesh side up and swept free from adhering salt. Another inspection is made for cuts,

scores, and grubs, after which they are sorted according to grade, and classified as firsts and seconds, brands, cows, and steers. The No. 1 hides are rolled up with hair out, and the No. 2 with flesh out. After rolling (figure 13), they are tied, weighed, and further classified as heavy, spready, medium, light, and extreme.

**Sweep tare.**—In taking-up hides a tare allowance is made,

**Figure 14.—Checking off a load of hides.**

determined by what is known as the sweep tare. Ten hides are selected at random, weighed, swept thoroughly both on flesh and hair sides, and weighed again. The loss in weight is then taken for the whole pack. If this tare is not satisfactory to either buyer or seller, another lot of 10 hides is taken, and the average loss on the 20 hides indicates the tare allowance. Since the time of year has some influence on the tare allowance, it is usually determined before the hides are taken-up. For instance, July hides, on account of short hair, are given an allowance of 1 to 1½ lb., whereas March hides, having long hair, are given an allowance of 2 to 2½ lb. Figure 14 shows hides arriving at a tannery, and figure 15 depicts a typical hide cellar.

**Grubs.**—Among the defects found in hides, note should be made of the damage caused by the "bot-fly" or "warble fly" (*hypoderma bovis*). The grub deposits eggs in the animal; but just how, is open to controversy. Observations by workers in the Department of Agriculture, Bureau of Animal Industry, both of the United States and Canada, indicate conclusively that the eggs are deposited in the hair while the ani-

**Figure 15.—A hide cellar.**

mal is in a reclining position. According to a report of Dr. Seymour Hardwin, he observed a fly on the ground near a recumbent cow. It ran backwards, reached upward from the ground, and oviposited on the hair hanging down around the coronet. On another occasion a fly on the ground ran backward in the same manner, and oviposited about six inches below the point of the ischium, where the cow's body came in contact with the ground. From this point it laid eggs at intervals all along the side near the ground, as far forward as the elbow, without touching the animal except with the ovi-

positor. This journey took some time, as the fly rested one or two minutes after ovipositing. With regard to irritation, Dr. Hardwin observed that while the animal was recumbent no annoyance was apparent, probably because the fly was on the ground, but when standing it was a different matter, as the fly was forced to grasp the hair while ovipositing.

An extended series of experiments have shown conclusively that the larvae enter the animal both through the skin and by the mouth. In either case, the parasite travels along a pretty definite route, passing down the gullet to the diaphragm, and then through connective tissue along the sides and vertebrae to the back. The larvae found in the oesophagus, spinal canal, and subcutaneous tissue all had about the same dimensions. Signs of their migration through the intervening tissue were also found, proving that the process is continuous. On reaching the back, the larvae develop, and here force their way through the hide, first causing a swelling during their pupal stage, and finally making a puncture, falling, an undeveloped grub, to the ground where it matures.

In small numbers, warble flies do little injury to the health of the animal, although cases are on record where an excessive number of grubs have caused death. The holes produced by the grub soon heal, but if the animal is killed before the healing is complete, they remain open and are a source of damage to the hide. Preventive measures are being taken in some States to overcome this nuisance, and it is hoped that they may become general practice.

Hides from certain countries may be damaged by ticks, but the injury, however, appears only in the shanks, and is not so serious as that caused by grubs.

**Grub allowance.**—The grubbing of native steers is permitted and a grub allowance made between January 1 and June 1. This is done by sampling. The hides selected for grubbing, twenty in number, are spread on the floor, and the purchaser's agent, by means of a spade, finds as many grubs as possible. When all grubs have been found to a limit of five, another hide is examined, and so on. If the number of

grubs found is not satisfactory to either buyer or seller, another 20 hides are taken, and the grub allowance based on the 40 hides so chosen.

**Hide selections.**—When purchasing hides, the buyer looks for certain selections, depending on the kind of leather he is

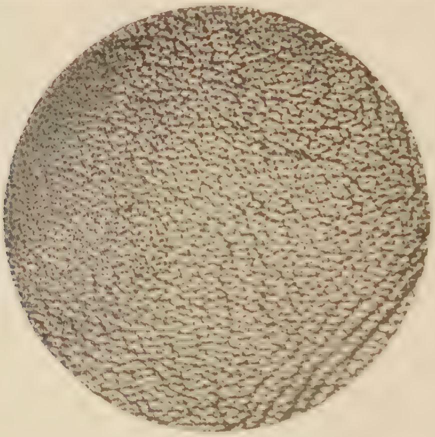

**Figure 16.—Cowhide, showing character of grain.**

producing and the market conditions. Figure 16 shows characteristic features of finished grain.

*Native steers.*—Steer hides free from brands are graded according to weight as heavy hides, above 60 lb.; light hides, between 50 and 60 lb.; and extremes, between 35 and 50 pounds.

Heavy hides are usually kept separate and sold for belting leather. Light hides sell for one cent less per pound, and extremes for two cents less, than heavy hides. Kosher hides are included in regular lots, and are sold for ¼ cent reduction.

*Spready hides.*—Native steers going into this selection must be perfect in all respects, free from brands and grubs. In the Western States the measurement of a spready hide must be 6 feet 6 inches across the shoulders just back of the brisket, whereas in the East the measurement is 6 feet 8 inches. Hides of this class are used largely for furniture and automobile upholstery. As winter-killed hides are likely to

be very grubby, the tanner prefers to purchase stock killed from June to January. These hides bring the top prices today, while several years ago they went at lower figures than other stock.

Spready native cows must be perfect and measure 6 feet 4 inches across the brisket, and go into the same trade as spready steers.

*Texas steers.*—These hides are from branded range cattle, and on account of their plump condition find a ready market in the sole-leather trade. The cattle themselves, however, are underfed, and are known at the stockyards as "bone creter." Conditions, nevertheless, are changing, and the quality of the beef as well as of the hides is improving. Texas steers are butt-branded. The grubbing privilege extends from November 1 to June 1.

*Colorado steers.*—The hides from Colorado steers are side-branded either on one or both sides. As a rule they are more spready and have a more spongy feel than Texas hides. The grubbing privilege extends from December 1 to June 1. They are selected as heavies, over 60 lb.; lights, 50 to 60 lb., and extremes, 25 to 50 pounds.

*Cowhides.*—The so-called native cowhides are free from brands, and are graded as heavies, over 55 lb., and lights, under 55 lb. Branded cows on the other hand are sold flat for weights. Both selections are grubbed from November 1 to June 1, with the usual allowance of ¼ cent off in case of kosher hides.

*Bull hides.*—The hides known as native bulls are free from brands and stags. They are not grubbed and are usually sold flat. Branded bulls are also sold flat and not grubbed. Bull hides are recognized by their tough pate, thick and ribby neck, and thin butt. As a rule, spready bulls are not sorted out. Some tanners, however, prefer selection, and in such cases the sorting is done by the broker.

*Country hides.*—Green-salted hides not taken off by the large packers are known as country hides, but they may be from the same kind of cattle as those killed by the packers.

The principal difference is in the flaying, which is poorly or imperfectly done, the hides being badly cut, scored, and of poor pattern. These hides come from farmers or country butchers, who either salt them lightly or sell them green to small collectors, who in turn sell them either direct to the tanner, or, as is more often the case, to the large dealers. The latter sort the hides into different grades and weights, so that the tanner can obtain the selection desired. As a rule, the hides have been salted and re-salted several times, which imparts to them a dark flesh color, with a consequent loss of hide substance. The defects of country hides include scores, grubs, hairslips, and poor patterns. Badly damaged hides are thrown into glue stock.

**Kips.**—Hides from undersized animals or large calves are sold as kipskins, and range in weight from 15 to 25 lb. Branded or grubby skins go into seconds, and are sold at the proper reduction.

**South American hides.**—River Plate hides, or "straight hides" as they are known in the trade, come from South and Central America. These are dry hides shipped from Argentina and Uruguay, and are spoken of as "Buenos Aires" and "Montevideos," taking their name from the point of shipment. These hides are from range cattle and are considered the best dry hides on the market. Other hides also take their names from the point of shipment and are known as "Puerto Cabellos," "Maracaibos," "Caracas," "Costa Ricas," "Central Americas," and "Orinocos." They vary in character as to plumpness and quality of grain. Salted hides imported from South America come in as "frigorificos," "saladeros," and "metaderos." Frigorificos are hides from animals the meat of which is shipped from Argentina as frozen beef; saladeros are from the smaller packing-houses of Argentina and Uruguay; while metaderos are hides from the village butcher and correspond to American country hides. Other dry hides come into this market from China and India.

**Anglo-American hides.**—These are hides taken from cattle shipped to England on the hoof. They have all of the

characteristics of packer hides, except that they have a short shank, and so bring a somewhat better price than packer hides.

**Swiss and Bavarian hides.**—Hides coming from this source are in great demand for the manufacture of belting leather. The reason for this is that they are from animals raised by peasants, who have given them the best of attention. They are plump and heavy, and have a very clear grain.

**Calfskins.**—All skins under 15 lb., except slunks, are sold as calfskins. The following is the common classification:

| | Weight, pounds |
|---|---|
| *Slunk* | |
| No. 1 and 2 light deacons (country take-off) | 7 down |
| No. 1 and 2 heavy deacons (country take-off) | 7 to 8 |
| No. 1 and 2 light calf (butcher take-off) | 7 to 8 |
| *Calf* | |
| No. 1 and 2 veal hair | 8 to 15 |
| Kip (veal, 1st grade) | 15 to 25 |
| Kip (grasser, 2nd quality) | 15 to 25 |
| No. 1 and 2 runner kip (light kip, poor hair) | 15 down |
| No. 1 and 2 extreme cows (known as extra light) | 25 to 45 |
| No. 1 and 2 buff or medium cows | 45 to 60 |
| *Cows* | |
| No. 1 and 2 light steers | 45 to 60 |
| No. 1 and 2 heavy steers | 60 up |
| No. 1 and 2 light bulls | 45 to 60 |
| No. 1 and 2 medium bulls | 60 to 85 |
| No. 1 and 2 heavy bulls | 85 up |
| No. 1 and 2 stags are classed with bulls. | |
| *Trimmed calf and kip* | |
| Calf | 4 to 5 |
| Calf | 5 to 7 |
| Calf | 7 to 9 |
| Calf | 9 to 12 |
| Kip | 12 to 16 |
| Kip | 16 to 20 |

Figure 17 shows the grain on finished calfskin.

Packer hides are thrown into seconds if they have one cut or five grubs. Country hides are thrown into seconds if they have one cut and one grub. A side or butt brand throws a hide into second grade.

**Horsehides.**—These hides are obtained from domestic sources, and come mostly from work horses which have died in service. The best hides, however, are imported from France and Russia. These hides are sold by the piece ac-

cording to size and condition of the butt. The butts are cut off 21 inches from the tail, the cut being made clear across the hide. These butts are used for making the leather known as "cordovan," also for making a heavy leather worn in cold countries like northern Russia. The remaining portions of the hides, known as "fronts," are used for making shoe and glove leather, and are usually not tanned by the same firm handling the butts. No. 1 horsehides must be free from cuts, scores, brands, or dragged spots. Seconds are those having

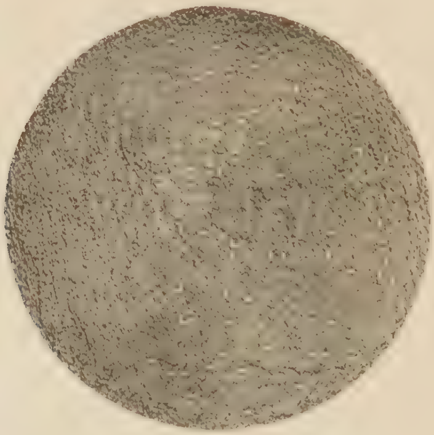

**Figure 17.—Calfskin, showing grain on finished leather.**

these imperfections. There is also a difference between summer and winter hides: In the summer, many horses die from exhaustion, and, as a rule, are not skinned promptly, some even lying several days in the street before removal. Decomposition is going on all the time, and dragged spots occur. As the animal had been in imperfect health, this disturbance is reflected in the hide. Winter hides, on the other hand, are taken from animals killed after an accident, such as slipping on frozen pavements. The animals are in a healthy condition, and the hide is full of life and much stronger than summer hides, also much thicker. Even if the horse lies in the street, there is comparatively no putrefaction of the hide, which,

consequently, does not show dragged spots. Figure 18 shows the characteristic grain of finished leathers.

**Goatskins.**—These come chiefly from those countries in which the meat is used for food. Goat meat is not a popular article of diet in America, consequently practically no domestic skins are available. We, therefore, depend upon the Orient, Asia, Africa, and South America for our raw material, and as more goatskins are tanned in the United States than in any other country, we have become the greatest importers for this grade of stock. As a rule, goats are not raised in herds like cattle or sheep, but are obtained from peasants who always have a few animals on their farms. These are gradually gathered by small collectors, who pass them on to the larger dealers. The dealer then brings them to the market place where they are bought by the big exporter, who in turn ships them to the United States or other countries.

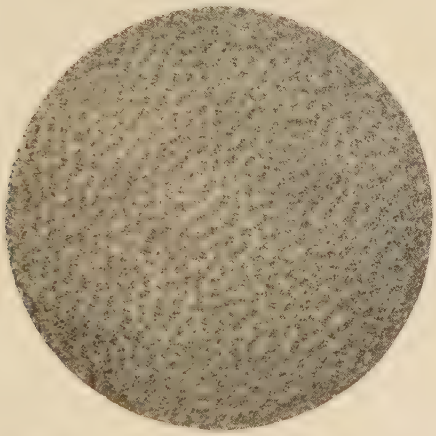

**Figure 18.—Horsehide, showing character of grain.**

The picking up and shipping of skins varies greatly in different countries, so that at certain seasons of the year stock comes in from one country, and, at another season, we find the market loaded with skins from an entirely different country. The climatic conditions of a region, of course, affect the nature of the skin. Excessively wet or dry seasons have

their influence upon the raw material, and in cold climates the skins take on a heavy growth of hair, while in warm climates the hair is short. The longer the hair, or the more closely the animal approaches the sheep, the poorer the pelt is for leather purposes. Figure 19 shows the natural grain on domestic goatskins.

*Curing.*—Skins are cured in the same manner as hides, but inasmuch as they are thin and small, the details of the process are somewhat modified. The simplest method consists

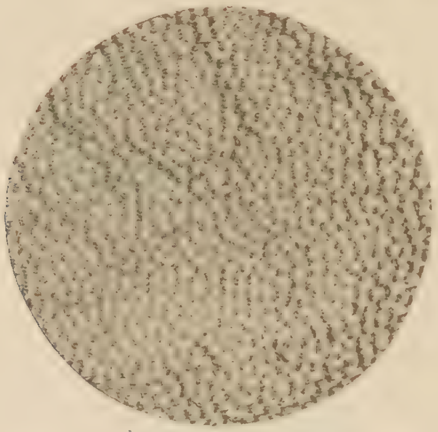

**Figure 19.—Goatskin, showing grain on finished leather.**

of sun drying, where the skins are either spread out or hung up in the sun until dry. If the sun is too hot they are hung in the shade. Dry-salted skins are given an application of salt, and then dried in the sun or shade. Wet-salted skins are rubbed thoroughly on the flesh side with salt, folded into small bundles, and packed in barrels or casks. The dried skins are placed in bales, and a small quantity of naphthalene is put between each skin. This prevents moths and bugs from damaging the stock, and overcomes the tendency to heat. Skins from some countries are arsenic-cured, but this should be avoided as much as possible.

Goatskins, as they come to the tanner, are designated by the name of the country or province from which they come,

or from the point of shipment. They are graded according to weights and selections somewhat as indicated below:

| *From China* | *Average weight, pounds* |
|---|---|
| Light | 1.25 |
| Medium | 2.00 |
| Heavy | 2.50 |
| Bulls | over 3.00 |

| *From India* | *Weight, pounds* |
|---|---|
| Lights A's | 0.75 |
| Regular B's | 1.00 |
| Large C's | 1.50 |
| Heavy D's | 2.00 |
| Bulls, BB's | over 2.00 |

| *Northwestern and Amritsars from India* | |
|---|---|
| Lights | 1.25 |
| Mediums | 1.50 |
| Heavies | 2.00 |
| Bulls | over 2.00 |

| *Regular South American* | |
|---|---|
| Light A's | 0.75 |
| Regular B's | 1.15 |
| Medium C's | 1.50 |
| Heavy D's | 2.00 to 2.50 |
| Bulls, BB's | over 2.50 |

| *Brazilian* | |
|---|---|
| Light A's | 0.75 |
| Regular B's | 1.00 |
| Medium C's | 1.50 |
| Heavy D's | 2.00 |
| Bulls, BB's | over 2.00 |

Figures 20 and 21 show goatskins as they arrive at a tannery.

*Spanish goatskins.*—These skins are noted for their fine grain, plumpness, and freedom from imperfection. They are cut open and folded down the back. The best are obtained from Valencia, Catalonia, Barcelona, and Seville; good skins also come from Leon and Castille, but those from the territory near the Portuguese boundary are inferior. Spanish skins come into market under the following selections:

| *Class* | *Weight, pounds* |
|---|---|
| No. 1 and 2 lights | 1.25 |
| No. 1 and 2 regulars | 2.25 |
| No. 1 and 2 heavies | 2.50 |
| No. 1 and 2 extra heavies | 3.00 |

Figure 20.—Warehouse in a goatskin tannery; stock being received and weighed.

Figure 21.—Raw stock. Goatskins come from all parts of the world They arrive in a dry condition and before tanning are sorted into various grades and weights.

In addition to these there are small kidskins used for glove leather. The light skins are sometimes known as "chevrettes."

*German goatskins.*—Most of the skins produced in Germany are used by the domestic trade. In case of shipment, however, the best skins are retained, and a selection of A, B, and C's, corresponding to first, second, and third, are sorted for export, and are known as American selections.

*Italian goatskins.*—Those from the northern part of Italy are of the best quality, and come from the districts of Rome and Tuscany. They are flat dried and selected for primes and seconds, which yield a good-weight leather. Skins from the southern provinces are of an inferior quality. They come from Naples, Puglia, Calabria, and the Island of Sicily. The Sicilian skins are known as Messinas and Palermos. These skins weigh from $2\frac{1}{2}$ to 3 lb. each.

*Southern Europe goatskins.*—Many skins originate in that part of Europe comprising Austria, Hungary, and the Balkan countries. Most of these skins are of good quality with fine grain, and are usually taken off the animal in such a manner that they remain "cased," that is, not cut open. They are flint dried, and their weight averages from $3\frac{1}{4}$ to $3\frac{1}{2}$ pounds.

Serbian skins are limited in number, but are of the highest grade. The Bosnian skins are somewhat inferior in character. Other skins come from Greece, Montenegro, Macedonia, and Albania. Skins coming from these provinces are usually shipped from the port of Trieste, while some of those from Macedonia and Greece come from Salonica.

*Turkish goatskins.*—Under the general name of "Levant goatskins" are those originating in Asiatic Turkey. These skins are dry-salted, cut open, and folded flat. They are inferior to Balkan skins, being coarse in character and having considerable long black hair. The weight of the skins runs from $3\frac{1}{3}$ to $3\frac{2}{3}$ lb. each. The stock coming from the Mediterranean side is of about the same quality as Asiatic skins. From the southern district of Bagdad comes a skin which, on ac-

count of defective grain, gives a low-grade leather. After being taken off, the skins are cased, dry-salted, and stretched lengthwise. Their weight runs from 3 to $3\frac{1}{2}$ pounds.

*Russian goatskins.*—Taken as a whole, Russia, including Siberia and central Asia, produces more goatskins than any other country in the world. The skins are packed at various points, and are brought to the animal fairs held at Tyumen and Nijni Novgorod, when they find their way to the markets of Petropaulovsk, Orenburg, Kazan, and Semipalatinsk. Russian skins reaching America are known from the place of shipment, such as "Petropaul goat," "Turkestans," and "Bokharas."

Petropaul skins are flint-dried and are mostly white-haired. The summer skins are short-haired and plump, whereas winter ones are long-haired and thin. They are classified as "werchural," primes and seconds, 25 lb. per dozen; "mittel," primes, seconds, and winters, 20 lb. per dozen; and "lack" kids, 12 lb. per dozen.

These skins contain considerable natural grease, and although they produce a high-grade leather, the tanner often encounters trouble from spew.

Turkestan skins possess all the qualities of Petropaul skins, except that they are somewhat lighter.

Bokhara goatskins are almost identical with Turkestans, except that they are short-haired and mostly black. Many Afghanistan and Persian skins also find their way to the American market, and, as their quality is inferior, they have detracted from the real value of Bokhara skins. Their weight is about the same as other Russian skins.

*North African goatskins.*—The chief shipping ports for these skins are Algiers, Constantine, and Oran. The leather from all these skins is of fine grain and good quality. The hair is short and mostly white. They are cased and dry-salted, and are classified as heavies, weighing about 2 lb. each: middles, $1\frac{3}{4}$ lb.; and lights, $1\frac{1}{2}$ pounds.

Skins coming from Tunis and Sfax closely resemble those

coming from Algeria, although they are slightly inferior in grain and substance.

Tripoli and Bengari produce a large quantity of skins, plump in character and fine of grain, which produce a very good leather. Both salted and flint-dried skins come from this district.

High-grade skins are obtained from Morocco. Those from Tangiers and Fez are earthy salt-cured, cased, and of a brownish color. The hair is medium in length and of a reddish-brown color. Skins come into the American market also known as "Casablancas," "Mogadors," and "Marrakesh." The first mentioned are either red- or gray-cured, the red-cured skins being mostly cased. From Mogador and Marrakesh the stock is identical in character and of good quality. These skins are cut open, and cured with a mixture of salt and camel manure, but on account of this treatment, they do not keep well.

The Egyptian and Sudan skins are cased and salt-cured. The summer skins are short-haired and black, and, like other skins, are better during this season. The shipping points are Cairo and Alexandria. The selection includes: No. 1 heavies, 2.3 lb.; No. 1 mediums, 1.6 lb.; No. 1 lights, 1.25 lb.; No. 1 smalls, 1 lb.; and No. 2, 1 lb. to ¼ pound.

*South African skins.*—The skins from this country are known to the trade as "Capes." Depending upon the point of shipment, they are classified as "Capetowns," "Algoabays," and "Kaffirs." Of these classes the first are considered to be of the highest grade owing to their plumpness, fine grain, and white hair. Their cure is a light brine, and the skins are packed flat. The Algoabays are cured somewhat heavier than Capetowns; the hair is slightly longer and somewhat inferior in character. The Kaffir skins are inferior to the two grades first mentioned, being darker in appearance, having much longer hair, and being more heavily cured.

*Arabian goatskins.*—The skins coming from the region of the Red Sea include those from northeastern Africa and Arabia. They are known to the trade as "Mochas," originate largely

in the Yemen province, and are shipped from Aden or Hodeidah. Skins of a similar character also come by the way of Gataways. All of the skins are cased and dry-salted. The hair is short and is mixed black and white. The selections include heavies, weighing from 2 to 2¼ lb. each; regulars, about 1¼ lb.; seconds, from 1 to 1 1/5 lb.; and long hairs, kids, and thirds.

Many skins coming from this region and packed in Abyssinia, are known as "Herrar" skins; while skins are also obtained from Massowah, Somali, Mogdeshur, Mombassa, and Zanzibar.

*Indian goatskins.*—The most important country in the world for goatskins is India, which produces 30 per cent of the entire supply. Not only are thousands of skins exported in the raw condition, but many are bark-tanned by the natives and come into the market as "India-tanned." The best known and most highly prized Indian skins are the so-called "Patnas," which derive their name from the city of Patna in the Province of Bengal, from which they are shipped. East of Patna is a district furnishing the skins known as "Daccas." The Patna skins are dry-salted and tacked, whereas Daccas and Dinajpores are dry-salted and not tacked.

The best Indian skins are produced in the district around the estuary of the Ganges, and are known as "Kushtias" and "Calcutta daissees." These skins are classified according to weight as follows:

| *Class* | *Pounds per* 500 *pieces* | *Class* | *Pounds per* 500 *pieces* |
|---|---|---|---|
| Extra heavies | 850 to 950 | Smalls | 300 to 350 |
| Heavies | 700 to 750 | Kids | 250 to 300 |
| Medium | 500 to 575 | Heavy seconds | 750 to 850 |
| Light | 400 to 475 | Medium seconds | 450 to 500 |

Many skins are obtained from other provinces of India, among which may be mentioned "Oudhs," "Agras," "Punjabs," "Amritsars," and "Madras."

*Chinese goatskins.*—These are of about the same nature, regardless of the port of shipment. They are classified as long hairs, medium hairs, and short hairs, the last being the best

quality. The principal ports from which the skins are shipped are Tientsin, Chowching, Shantafoo, Pastingfoo, Hankow, Honan, and Shanghai.

*South American goatskins.*—Argentina and Brazil are the chief countries in South America furnishing goatskins. Those from Brazil are more in demand and most highly prized by the tanner. These skins, named from the port of shipment, are known as "Buenos Aires," "Pernambucos," etc.

A considerable number of skins also come from Mexico and the West Indies.

**Hogskins.**—These, as a rule, are not taken off by the butcher, as the method of removing the bristles consists of

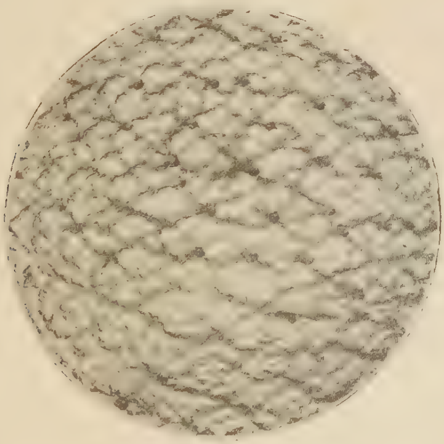

**Figure 22.—Hogskin, showing characteristic grain.**

scalding and scraping the carcass. Figure 22 shows the characteristic grain.

In some establishments, however, the skin is removed, but even then the take-off is very poor. Hogskins are desirable for certain purposes, and there seems to be a growing demand for leather made from this raw material. Skins from across the shoulders are the most desirable, and of course bring the highest price.

For a number of years, bacon strips have been worked into

a marketable article, and find a growing demand in the trade.

**Sheepskins.**—Of all the pelts of animals used in making leather that of the sheep exceeds all others. It is estimated by Alfred Seymour-Jones that there are more than 600,000,-000 sheep in the world, and of this number from 25 to 40 per cent is slaughtered every year. As sheep are raised for their wool and flesh, and not for their skins, many of the lat-

**Figure 23.—Skinning out the legs of a sheep.**

ter are lost, but owing to the increased demand, this waste is gradually decreasing. The decline in the number of sheep—as well as cattle—being raised is a factor which is giving the tanner considerable cause for alarm. Figures 23, 24, 25, and 26 show some of the steps in flaying sheep.

Although sheep form a separate group of animals, they pass by gradual stages into the goat classification. Thus the pelt may range from one with wool to one with coarse hair, while some sheep possess no hair nor wool.

The character of sheepskins depends upon the condition of the environment and method of feeding the stock. Soft-wooled skins possess a fine grain, while long-wooled skins have, as a rule, a coarse, tough grain. Generally, the more woolly a skin is the more fat is found on the pelt; on the

Figure 24.—Skinning over the flank of a sheep.

other hand the less wool the skin carries the nearer the pelt approaches the character of the goat.

Sheepskins are subject to numerous afflictions, all of which worry the tanner when he tries to convert the raw material into leather. The worst enemy to the sheep is the fly, or parasite, which acts as a means of transmitting disease from one animal to another. The diseases produced by parasites are sturdy or giddiness, louping ill and scab, while other damages are caused by fly-blow, and ticks.

Of these various afflictions, that of scab is the most formidable on account of its persistence and difficulty of eradication. The presence of the disease is indicated by the falling of the hair from the part affected. If examined under the microscope, it will be noticed that the surface shows an eruption, and that numerous insects may be seen moving in and

Figure 25.—Stripping-off over the back of a sheep.

out among the hair roots. If the parasite is not killed, the disease will spread over the entire body.

*Sheep kids.*—This pest is probably the most widely distributed of the parasites attacking sheep. It belongs to the same

order as the common house-fly, but is wingless. The kid does not lay eggs, but hatches them in the body of the parent insect. When the maggot is deposited, the development is so far advanced that it becomes a pupa under cover of the puparium. Each female produces above five pupae, at intervals of a few days, after which it dies. The mature insect sucks the blood

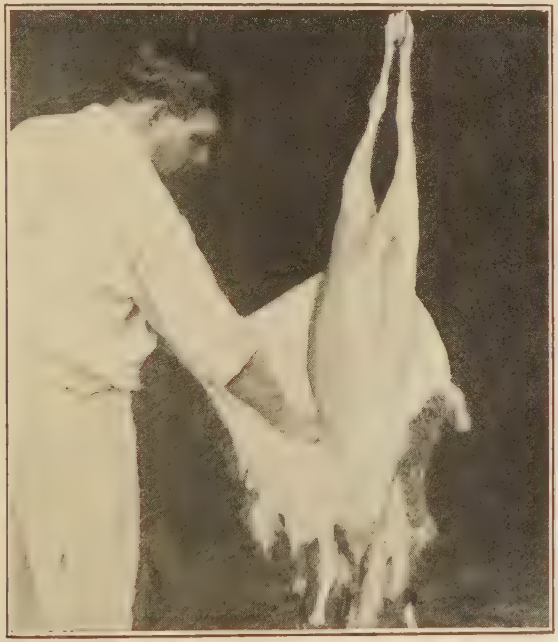

**Figure 26.—Fisting off a sheepskin.**

of the animal, causing great irritation at the point of attack.

*Sheep ticks.*—The eggs of this insect are laid in large numbers in swampy places; the larvae, on hatching, attach themselves to sheep, and, after feeding, fall to the ground and moult, after which they become nymphae. Again they attach themselves to the sheep, and after feeding fall off and moult a second time, then becoming adults. Once again as adults, they gorge themselves with blood, and the females fall to the ground for egg-laying. The ticks are found in sheep during the spring and summer months. The injury caused by the

blood-sucking is that minute holes are made through the grain, thus causing a local inflammation, which destroys the grain and even the skin for some distance around the puncture.

*Lice.*—These insects are very common on sheep, their presence indicated by falling hair, itching, irritation, and unrest. The injury to the grain is somewhat similar to that caused by ticks.

*Fly-blow.*—This is caused by sheep maggot-fly. The fly deposits the eggs upon the backs of the longer-wooled

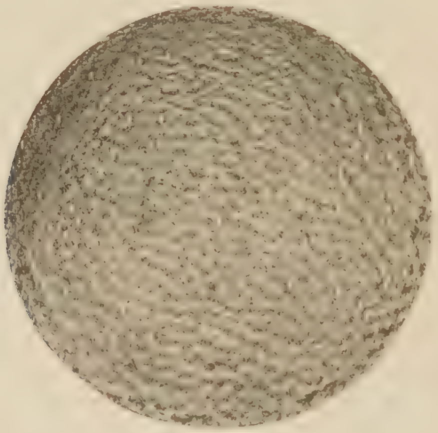

**Figure 27.—Sheepskin, showing characteristic grain.**

sheep, as deep in the wool as it can reach. The act of depositing the eggs is termed "striking," by the sheepman. The eggs hatch quickly, and the larvae burrow into the skin, causing excruciating pain, which, unless treated, may often cause the death of the animal, a death due to the sheep being eaten by the maggot while alive.

Sheepskins come to the tanner either in the hair or in a pickled condition. The latter skins have been pulled by the fellmonger for the wool. The largest number of skins come from New Zealand and the British Isles, while, at the same time, a considerable number of domestic skins are available Figure 27 shows characteristic grain.

**Other hides and skins.**—Although the hides and skins enumerated constitute the bulk of the raw material from which leather is produced, it must not be concluded that they are the only source, as the covering of many other animals—even the skin of fish—enters into the production of this commodity.

Without going into detail, it may be well to mention that a large amount of leather is produced from the covering of the deer, kangaroo, buffalo, dog, seal, walrus, shark, porpoise, whale, sturgeon, alligator, crocodile, lizard, and many others;



Figure 28.—Lambskin.

Figure 29.—Kid skin.

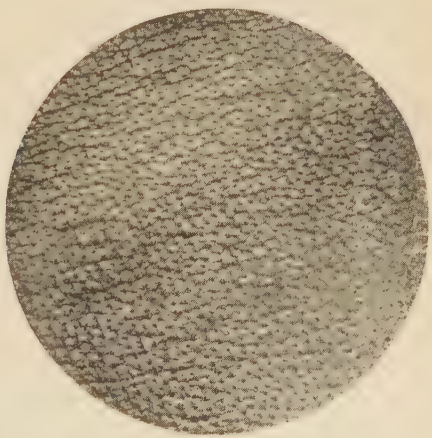

Figure 30.—Kangaroo skin.

while furs are produced from a large variety of animals. Figures 28, 29, 30, 31, 32, and 33, represent the characteristic grain of the various kinds of skins indicated.

**Disinfection of hides.**—The number of hides and skins imported into the United States annually amounts to many millions, (700,000,000 lb., exclusive of furs, in 1920, calculated on a "green" basis, when 1 lb. of dry hide equals 2 lb. of green hide). Since these hides and skins come from all parts of the globe, there is great danger of their bringing in

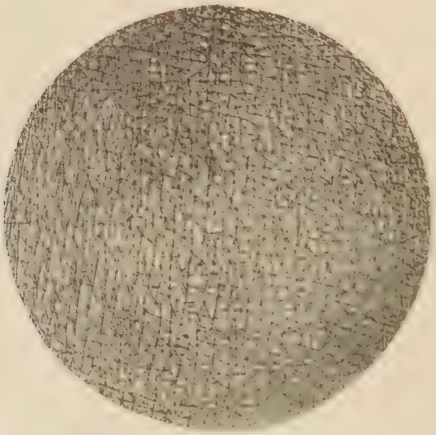

Figure 31.—Human skin.

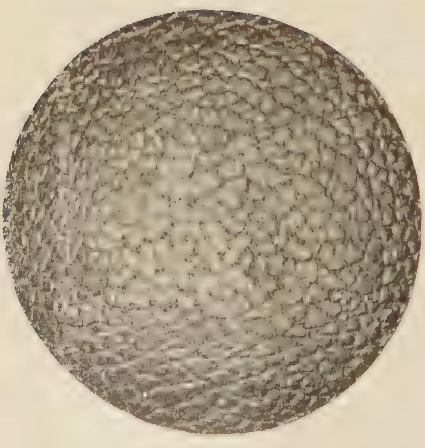

Figure 32.—Sealskin.

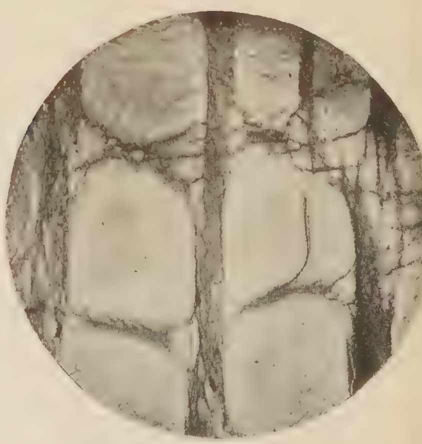

Figure 33.—Alligator skin.

infectious diseases, among the most dangerous of which is anthrax. As the anthrax spore has great resisting power, many methods of disinfection have been suggested. Among the numerous processes which have been suggested, that proposed by Seymour-Jones has attracted much attention. Other methods have been investigated, among them being the treatment devised by Schattenfroh.

Seymour-Jones purposes to use mercuric chloride and formic acid. By this method it is claimed that the formic acid causes the hide substance to swell, thus furnishing a favorable condition for the action of this salt. The dilutions recommended are 1 part mercuric chloride in 5,000 parts of water, and 1 per cent of formic acid, and time of treatment 24 hours. After disinfection, the hides are placed in a 10° Bé. salt solution when they will fall, and thus be brought to the condition of green-salted stock.

The Schattenfroh method consists in immersing the hide for 48 hours in a 10° Bé. salt solution containing 2 per cent of hydrochloric acid. This method is being carried out in many tanneries, and by replenishing the hydrochloric acid removed by the hide, is much less expensive than the Seymour-Jones process.

The above methods for disinfection in the case of anthrax apply equally well for other infections, such as rinderpest and foot-and-mouth disease.

**Regulation of the U. S. Government.**—The Government regulations covering disinfection are set forth in the following orders:

UNITED STATES TREASURY DEPARTMENT AND DEPARTMENT OF AGRICULTURE

**Regulations Governing the Sanitary Handling and Control of Hides, Fleshings, Hide Cuttings, Parings, and Glue Stock, Sheepskins and Goatskins and Parts Thereof, Hair, Wool, and Other Animal By-Products, Hay, Straw, Forage, or Similar Material Offered for Entry into the United States.**

*Effective January* 1, 1918.

WASHINGTON, D. C., *October* 15, 1917.

Under authority of the act of Congress approved October 3, 1913, entitled "An act to reduce tariff duties and to provide revenue for the

Government, and for other purposes" (38 Stat., 114), and the act of Congress approved February 2, 1903, entitled "An act to enable the Secretary of Agriculture to more effectually suppress and prevent the spread of contagious and infectious diseases of live stock, and for other purposes" (32 Stat., 791), the following regulations are issued for the purpose of preventing the introduction of anthrax, foot-and-mouth disease, and rinderpest from a foreign country into the United States.

### Regulation I

#### HIDES AND SKINS

Section 1. All hides of meat cattle, calfskins, buffalo hides, sheepskins, goatskins, and deerskins offered for entry into the United States (except abattoir and hard, sundried hides and skins as hereinafter provided for) may be imported from any country maintaining an efficient veterinary inspection system when accompanied by a certificate signed by an official veterinary inspector of such country, or, in the absence of such official veterinary inspector, by a United States consular officer, stating that anthrax is not prevalent and that neither foot-and-mouth disease nor rinderpest exists in the locality in which the hides or skins originated. Those articles may also be imported from any country which does not maintain an official veterinary inspection system when accompanied by a United States consular certificate stating that anthrax is not prevalent, and that neither foot-and-mouth disease nor rinderpest exists in the locality in which the hides or skins originated. In lieu of a certificate showing the non-prevalence of anthrax and the non-existence of foot-and-mouth disease and rinderpest, a certificate signed by one of the aforementioned officials stating that the hides or skins have been disinfected under his supervision by any of the methods approved or which may hereafter be approved by the Chief of the Bureau of Animal Industry, will be accepted.

Sec. 2. All hides or skins offered for entry into the United States (except abattoir and hard, sundried hides and skins as hereinafter provided for) which are not accompanied by any of the certificates prescribed in section 1 of this regulation, or which are accompanied by certificates which do not comply with the requirements or purposes of these regulations, may be imported from any country upon the conditions that they will be consigned from port of entry to an establishment having proper facilities for their sanitary control and disinfection; that they will move from port of entry to the establishment in cars or approved containers, sealed either with customs seals or seals of the Department of Agriculture; that they will be handled at port of entry and en route to such establishment in accordance with the provisions of these regulations, and that they will be disinfected by one of the methods approved, or which may hereafter be approved, by the Chief of the Bureau of Animal Industry. Seals of the Department of Agriculture shall be affixed to said cars and containers only by inspectors of the Bureau of Animal Industry, or by customs officers, and may be broken only by inspectors of the Bureau of Animal Industry, by customs officers, or by other persons authorized so to do by the Bureau of Animal Industry. Customs seals shall in no case be broken except by customs officers.

### Regulation II

#### HARD, SUNDRIED HIDES AND SKINS, AND ABATTOIR HIDES AND SKINS

Section 1. Hard, sundried hides and skins may be imported without disinfection if certified as required in section 1 of Regulation I to be from a locality where anthrax is not prevalent, if the bales or hides are

distinctly marked for identification, each shipment showing invoice number, names and addresses of consignee and consignor, as such hard, sundried hides and skins so certified showing freedom from anthrax can be considered as having been disinfected by the process of curing and need not be submitted to any further treatment. Hard, sundried hides or skins may be imported without being certified to be from a locality where anthrax is not prevalent, upon the conditions prescribed in section 2, Regulation I, for the importation of uncertified hides and skins.

SEC. 2. Abattoir hides and skins taken from animals slaughtered in Sweden, Norway, Denmark, Australia, New Zealand, Great Britain, Uruguay, Argentina, Brazil, and Venezuela when accompanied by a certificate of an official veterinarian of the country where such animals were slaughtered showing that such hides or skins were taken from animals free from disease at the time of slaughter, may be imported into the United States without disinfection. Abattoir hides and skins from the countries specified. which are uncertified, and abattoir hides and skins from countries other than those specified, may be imported subject to the requirements of Regulation I.

## REGULATION III

### GLUE STOCK

Fleshings, hide cuttings, and parings, or glue stock may be imported without disinfection—

(*a*) If accompanied by a certificate signed by one of the officials mentioned in section 1 of Regulation I, showing the non-prevalence of anthrax in the locality of origin; or

(*b*) If shown upon entry to have been disinfected by heat; or

(*c*) If shown to have been disinfected by acidulation; or

(*d*) If shown to have been disinfected by soaking in a milk of lime or a lime paste; or

(*e*) If shown to have been dried by exposure to the action of the sun and air for a sufficient time to render each piece of the hardness of a sundried hide.

If the said materials are not accompanied by the certificate described in paragraph (*a*), and are not shown to have been treated by one of the methods above indicated, they may be imported, upon the condition that the consignee or his agent files a satisfactory bond or agreement that said materials and their containers will be handled or disinfected in a manner acceptable to the Bureau of Animal Industry before distribution from the factory or establishment to which consigned.

## REGULATION IV

### BONES, HOOFS, AND HORNS

SECTION 1. Bones, hoofs, and horns which are clean, dry, and free from pieces of hide, flesh, or sinews may be imported without disinfection.

SEC. 2. Bones, hoofs, and horns, with pieces of hides or tendons attached, and also horn piths, may be imported upon the conditions that said materials be forwarded to a factory or other establishment in cars or approved containers sealed in the manner prescribed in section 2, Regulation I, and that the consignee or his agent files a satisfactory bond or agreement that such materials and their containers will be handled or disinfected in a manner acceptable to the Chief of the Bureau of Animal Industry.

## Regulation V

### WOOL AND HAIR

Section 1. Raw wool or hair clipped from healthy live animals, scoured wool and hair, and noils of wool and hair which have been properly scoured may be imported without disinfection or certification.

Sec. 2. Picked or pulled wool or hair, when accompanied by an affidavit of the exporter designating the bales or packages thereof by their markings, indicating the consignor, consignee, and number of the invoice, and stating that all the wool or hair contained in the bales or packages came from animals free from anthrax, may be imported upon the conditions that the consignee or owner of the wool or hair, or his agent, files a satisfactory bond or agreement assuring proper facilities of disinfection at the establishment to which the shipment is consigned and that such wool or hair will be disinfected by proper exposure to a temperature of not less than 165° F. prior to any transfer or reshipment from such establishment. If such wool or hair is unaccompanied by the above-mentioned affidavit it may be imported upon condition that the consignee or owner thereof or his agent files a satisfactory bond or agreement assuring proper facilities for disinfection at the establishment to which the shipment is consigned and that all of such wool or hair will be disinfected by proper exposure to a temperature of not less than 200° F. for at least 15 minutes prior to any transfer or re-shipment from such establishment.

Sec. 3. Importation of abattoir pulled wool will be permitted without restrictions from any country maintaining an efficient veterinary inspection system, when accompanied by a certificate signed by an official veterinary inspector of such country, or, in the absence of such official veterinary inspector, by a certificate of a United States consular officer of the locality from which shipped to the effect that said wool was procured from sheep slaughtered therein and passed under Government inspection, and that in the process of wet pulling and drying it has been subjected to a temperature of not less than 165° F. Such certificate shall indicate the number of bales, marks, names, and addresses of consignor and consignee, locality of origin, date of shipment, invoice number, and transporting vessel, and shall also show that the consignment consists of abattoir pulled wool which, in the process of wet pulling and drying, has been subjected to a temperature of 165° F.

Sec. 4. Wool or hair not otherwise provided for in these regulations, or not complying with the provisions thereof, may be imported upon the conditions that such articles be shipped from port of entry to destination in cars or satisfactory containers, sealed in the manner prescribed in section 2 of Regulation I; that the destination be a factory or establishment having satisfactory facilities for disinfecting the same, and that they will there be disinfected by proper exposure to a temperature of not less than 200° F. for at least 15 minutes, or in such manner as may be directed by the Chief of the Bureau of Animal Industry, prior to any transfer or reshipment therefrom. Such wool or hair may be stored in bond at the port of entry, subject to shipment and disinfection, as herein provided, on being released from bond. The consignee, owner, or his agent will be required to file a satisfactory bond or agreement to fulfill all requirements as to shipment and disinfection.

## Regulation VI

### CERTIFICATES FROM OTHER THAN OFFICIAL VETERINARIANS AND CONSULAR OFFICERS

Section 1. Whenever it shall be determined by the Secretary of Agriculture, after investigation, that in any foreign country or locality thereof

in which no official veterinarian of the Government or United States consular officer is located, there is a satisfactory qualified official, authorized by the Government of such foreign country to sign and issue certificates stating that anthrax is not prevalent and that neither foot-and-mouth disease nor rinderpest exists in the locality from which articles enumerated in these regulations are shipped, to sign and issue other certificates, to make affidavits and other declarations, and to supervise the shipment of hides and skins, glue stock, and other animal by-products, as specified in the regulations, due notice will be given of such determination, and thereafter such official may sign and issue the said certificates, make the said affidavits and declarations, and supervise the shipment of hides and skins, glue stock, and other animal by-products, in manner and form prescribed in the regulations; and such acts performed by the said official shall have the same force and effect as if performed by an official veterinarian of the country of origin or by an United States consular officer.

Sec. 2. The name of each foreign official authorized to do and perform the acts specified in section 1 of this regulation, when submitted to and approved by the Secretary of Agriculture, will be published, and the Chief of the Bureau of Animal Industry shall file with each such official a copy of these regulations and copies of amendments which may hereafter be made thereto. No act specified in section 1, performed by a foreign official, shall be recognized unless performed by an official whose name has been published, as required herein, and whose authority to do such acts has not been revoked.

## Regulation VII

### HAY, STRAW, ETC., AND MEATS PACKED IN HAY OR STRAW

Section 1. On account of the existence of foot-and-mouth disease in the countries of continental Europe and South America, and the impracticability of disinfecting hay and straw used as the packing on meats offered for entry without injuring the meats for food purposes, the entry into the United States from any of those countries of any meats packed in hay or straw is prohibited.

Sec. 2. Bran, middlings, and mill feed may be imported from Argentina without being disinfected as prescribed in section 4 of this regulation if accompanied by an affidavit of the shipper, showing that such bran, middlings, or mill feed was conveyed by chutes directly from the mill in which produced into the vessels transporting the same to the United States.

Sec. 3. Because of lack of danger of the communication of disease through the importation of hay, straw, forage, and similar materials, including bran, middlings, or other mill feed originating in and transported directly from Great Britain, Ireland, the Channel Islands, Canada, and Mexico, such articles may be imported into the United States from these countries as long as the above condition continues to exist without being disinfected as prescribed in section 4 of this regulation.

Sec. 4. Except as otherwise provided in this regulation, all hay, straw, forage, or similar materials, including bran, middlings, or other mill feed, offered for importation from any foreign country, shall be disinfected in a manner prescribed by the Chief of the Bureau of Animal Industry, at the expense of the owner, before being unloaded from the vessel or conveyance bringing the same into any port of the United States, and when unloaded and landed shall be stored and held in quarantine for a period of not less than three months at some place acceptable to the Chief of the Bureau of Animal Industry, and under directions prescribed by him.

## Regulation VIII

### CANADA

Because of the lack of danger of the introduction of disease into the United States through the importation of the articles enumerated in these regulations originating in and transported directly from Canada, such articles may be imported from Canada as long as the above condition continues to exist without being disinfected or certified as prescribed by these regulations.

## Regulation IX

### PRODUCTS FROM DISEASED ANIMALS

Importation into the United States of any animal by-products, taken or removed from animals affected with anthrax, foot-and-mouth disease, or rinderpest, is prohibited.

## Regulation X

### METHODS FOR DISINFECTION OF HIDES, SKINS, AND OTHER MATERIALS

Hides, skins, and other materials required by these regulations to be disinfected shall be subjected to disinfection by methods found satisfactory and approved from time to time by the Chief of the Bureau of Animal Industry of the United States Department of Agriculture. The Chief of the Bureau of Animal Industry is authorized to revoke from time to time any methods which have been approved by him.

## Regulation XI

### DISINFECTION OF CARS, BOATS, OTHER VEHICLES, AND PREMISES

Section 1. Cars, boats, other vehicles, yards, and premises which have been used in the transportation, handling, and storing of uncertified or non-disinfected imported hides, skins, and parts thereof, hair, wool, and other animal by-products, hay, straw, forage or similar material, permitted entry subject to disinfection, shall be cleaned and disinfected under the supervision of the Bureau of Animal Industry as indicated in Regulation XII, and in the manner provided in sections 2 and 3 of this regulation. Except as hereinafter provided in these regulations, cars, boats, and other vehicles which have been used in the transportation of uncertified or non-disinfected imported hides, skins, and parts thereof, hair, wool, and other animal by-products, hay, straw, forage, or similar material, permitted entry subject to disinfection, shall not be moved in interstate or foreign commerce until the said cars, boats, and other vehicles have been cleaned and disinfected under supervision of the Bureau of Animal Industry in accordance with sections 2 and 4 of this regulation.

Sec. 2. *Paragraph 1.* Cars required by these regulations to be cleaned and disinfected shall be treated in the following manner: Collect all litter and other refuse therefrom and destroy by burning or other approved methods, clean the exterior and interior of the cars, and saturate the entire interior surface, including the inner surface of the car doors, with a permitted disinfectant.

*Paragraph 2.* Boats required by these regulations to be cleaned and disinfected shall be treated in the following manner: Collect all litter and other refuse from the decks, compartments, and all other parts of the boat used for the transportation of materials covered by these regulations, and from the portable chutes or other appliances or fixtures used

in loading and unloading same, and destroy the litter and other refuse by burning or by other approved methods, and saturate the entire surface of the said decks, compartments, and other parts of the boat with a permitted disinfectant.

*Paragraph 3.* Buildings, sheds, and premises required by these regulations to be disinfected shall be treated in the following manner: Collect all litter and other refuse therefrom and destroy the same by burning or other approved methods and saturate the entire surface of the fencing, chutes, floors, walls, and other parts with a permitted disinfectant.

SEC. 3. *Paragraph* 1. All hides, skins, and other materials subject to disinfection at destination under the provisions of these regulations shall be entered at ports having docking and unloading facilities separate and apart by not less than 100 feet, from yards, premises, roads, or runways where cattle and other ruminants and swine are kept, held, conveyed, or driven except for immediate slaughter. No animals of the species named, except for immediate slaughter, shall be permitted on any dock or premises where imported hides or other materials subject to disinfection at destination are being unloaded, stored, or handled within 24 hours following the completion of such handling, unless the said hides or other materials have been removed and the place or places where they were unloaded, stored, or handled, or with which they were in contact, have been cleaned and disinfected in a manner approved by the Chief of the Bureau of Animal Industry.

*Paragraph* 2. Except as otherwise provided in these regulations, all such hides, skins, and other materials subject to disinfection shall be loaded and shipped under official supervision and under seals as prescribed in section 2 of Regulation I.

*Paragraph* 3. Dust and refuse at docks, unloading places, and all warehouses and other establishments shall be controlled. All dust and other refuse shall be collected and destroyed by burning or other approved methods.

SEC. 4. *Paragraph* 1. The substances permitted for use in disinfecting cars, boats, other vehicles, and premises are as follows:

(*a*) Compound solution of cresol, U. S. P., at a dilution of at least 4 fluid ounces to 1 gallon of water.

(*b*) A permitted "saponified cresol solution" at a dilution of at least 4 fluid ounces to 1 gallon of water.

(*c*) Liquified phenol (liquified carbolic acid) at a dilution of at least 6 fluid ounces to 1 gallon of water.

(*d*) Chlorid of lime (U. S. P. strength, 30 per cent available chlorin) at a dilution of 1 pound to 3 gallons of water.

*Paragraph* 2. The use of "saponified cresol solution" as a substitute for compound solution of cresol, U. S. P., as a disinfectant is permitted, provided that such "saponified cresol solution" shall conform to the following requirements:

(*a*) The formula of the product shall employ not less than 28 per cent by weight of linseed oil. Either caustic potash, caustic soda, or a mixture of caustic potash and caustic soda may be used to saponify the linseed oil. The cresol used shall be at least 95 per cent pure, and enough of this commercial grade of cresol (cresylic acid) shall be employed in compounding the disinfectant to bring the actual amount of cresol in the finished product up to 50 per cent.

(*b*) The product shall remain a homogeneous liquid when cooled to 32° F. It shall contain substantially no unsaponified linseed oil or excess alkali. It shall be readily soluble in cold distilled water; the solution shall be practically clear and shall contain no globules of undissolved oil or cresylic acid.

(*c*) Manufacturers wishing to offer saponified cresol solution as indicated above for use in official disinfection shall first submit a sample of at least 8 ounces for examination, together with a statement of the formula

employed and a guaranty that the product will be maintained of a quality uniform with the sample submitted.

(*d*) To prevent confusion, each product shall bear a distinctive trade name or brand, together with the name of the manufacturer or distributor. There shall be no mention of the United States Department of Agriculture or the Bureau of Animal Industry on the labels, containers, or printed matter accompanying products permitted to be used in official disinfection. The permitted saponified cresol solution shall be used at a dilution of at least 4 ounces of the solution to 1 gallon of water.

## Regulation XII

### PLACARDING CARS AND MARKING BILLING

Section 1. Transportation companies shall securely affix to and maintain upon both sides of all cars carrying uncertified or non-disinfected imported hides, skins, and parts thereof, hair, wool, and other animal by-products, permitted entry subject to disinfection, durable placards not less than 5½ by 8 inches in size, on which shall be printed with permanent black ink and in bold-faced letters not less than 1½ inches in height the words "UNCERTIFIED IMPORT ANIMAL PRODUCT." These placards shall also bear the words "CLEAN AND DISINFECT THIS CAR." Each of the waybills, conductors' manifests, memoranda, and bills of lading pertaining to such shipments shall have the words "UNCERTIFIED IMPORT ANIMAL PRODUCT, CLEAN AND DISINFECT CAR," plainly written or stamped upon its face. If for any reason the placards required by this regulation have not been affixed to the car, or the billing has not been marked by the initial or the connecting carrier, or the placards have been removed, destroyed, or rendered illegible, the placards shall be immediately affixed or replaced, and the billing marked by the initial of connecting carrier, the intention being that the billing accompanying the shipment shall be marked and the car placarded as herein specified from the time such shipments leave the port of entry until they are unloaded at final destination and the cars are cleaned and disinfected as required by Regulation XI.

Sec. 2. If it is necessary to unload enroute any of the products specified in this regulation, the car from which the transfer is made and any part of the premises at the point of transfer which may have been contaminated shall be cleaned and disinfected by the transportation company, in accordance with the provisions of Regulation XI, and the transportation company shall immediately report the transaction by telegraph, to the Chief of the Bureau of Animal Industry, Washington, D. C. Such report shall include the information indicated as follows: (*a*) Nature of emergency; (*b*) place where product was unloaded; (*c*) original points of shipment and destination; (*d*) number and initials of the original car; also number and initials of the car into which the product is reloaded in case original car is not used.

Sec. 3. Cars required by these regulations to be cleaned and disinfected shall be treated in the manner specified in Regulation XI, under the supervision of the Bureau of Animal Industry, by the final carrier at destination as soon as possible after unloading and before the same are moved from such final destination for any purpose except as otherwise hereinafter provided.

When the products are destined to points at which an inspector of the Bureau of Animal Industry and proper facilities are maintained, the cars shall be cleaned and disinfected at such points under supervision of such inspector.

When the products are destined to points at which an inspector or other duly authorized representative of the Bureau of Animal Industry is not maintained, the transportation company shall seal, bill, and forward

the infectious cars to a point to be agreed upon between the transportation company and the Bureau of Animal Industry, and at which an inspector is maintained. The transportation company shall there clean and disinfect the said cars under the supervision of the Bureau of Animal Industry.

When the products are destined to points at which an inspector of the Bureau of Animal Industry is maintained, but at which proper facilities can not be provided, the transportation company may, upon permission first secured from the Bureau of Animal Industry, seal, bill, and forward the cars to a point at which an inspector of the Bureau of Animal Industry is maintained and proper facilities provided, and there clean and disinfect the said cars under the supervision of the Bureau of Animal Industry.

### Regulation XIII

#### TERRITORIAL POSSESSIONS

These regulations shall be applicable to all hides, fleshings, hide cuttings, parings, and glue stock, sheepskins and goatskins and parts thereof, hair, wool, and other animal by-products, hay, straw, forage, or similar material which is offered for entry into the United States from any place under the jurisdiction of the United States to which the animal quarantine laws of this country do not apply.

### Prior Order Annulled

Treasury Department and Department of Agriculture Joint Order No. 1, of October 21, 1916, and all amendments thereto, shall cease to be effective on and after January 1, 1918, on and after which date this order, which for purposes of identification is designated as United States Treasury Department and Department of Agriculture Joint Order No. 2, shall become and be effective until otherwise ordered.

L. S. Rowe,
*Acting Secretary of the Treasury.*
D. F. Houston,
*Secretary of Agriculture.*

## UNITED STATES DEPARTMENT OF AGRICULTURE

#### BUREAU OF ANIMAL INDUSTRY

**Special Order Prescribing Methods for the Disinfection of Hides, Skins, Fleshings, Hide Cuttings, Parings, and Glue Stock, and Other Animal By-Products, Hay, Straw, Forage, or Similar Material Offered for Entry into the United States, and the Containers of Glue Stock, Bones, Hoofs, and Horns so Offered for Entry.**

United States Department of Agriculture,
Bureau of Animal Industry
District of Columbia, *December* 14, 1917.

In accordance with the provisions of the United States Treasury Department and Department of Agriculture Joint Order No. 2, of October 15, 1917, "Regulations governing the sanitary handling and control of hides, fleshings, hide cuttings, parings, and glue stock, sheepskins and goatskins and parts thereof, hair, wool, and other animal by-products, hay, straw, forage, or similar material offered for entry into the United States," the following methods for the disinfection of the above-named materials and articles are hereby prescribed, effective January 1, 1918.

I. DISINFECTION OF HIDES AND SKINS PRIOR TO SHIPMENT

Hides and skins disinfected prior to shipment as provided by regulation 1, section 1, of said Joint Order No. 2, must be disinfected by one of the following methods:

(*a*) By immersion for not less than 24 hours in a 1 to 1,000 bichlorid of mercury solution.

(*b*) By immersion for not less than 20 hours in a solution containing 2 per cent absolute hydrochloric acid (hydrogen chlorid) and 10 per cent sodium chlorid.

(*c*) By immersion for not less than 40 hours in a solution containing 1 per cent absolute hydrochloric acid (hydrogen chlorid) and 10 per cent sodium chlorid.

(*d*) By immersion for not less than 24 hours in a solution containing 1 per cent formic acid, and mercuric chlorid in the proportion of 1 part to 2,500 parts of the solution. Hides or skins treated by this process shall be held for two weeks following the treatment before neutralization.

(*e*) By de-hairing and pickling in a solution of salt containing a definite percentage of mineral acid and packing in barrels or casks while still wet with such solution, provided the hides or skins are not neutralized within 30 days after being so packed.

II. DISINFECTION OF HIDES AND SKINS AFTER ARRIVAL IN THE UNITED STATES

Hides and skins required by Regulation 1, section 2, and Regulation 2 of said Joint Order No. 2 to be disinfected on arrival at a United States port of entry shall be moved to an approved warehouse at such port or in sealed cars or containers to an establishment having proper facilities for their sanitary control and disinfection. They shall be stored and handled prior to disinfection in compartments set aside for that purpose, and all hides and skins stored or handled in such compartments shall be treated in accordance with the following rules:

1. All dust, litter, or waste arising from sorting, cutting handling, or moving said hides or skins prior to soaking shall be burned or disinfected by exposure to a temperature of not less than 100° C. (212° F.) moist heat for not less than 15 minutes.

2. The hides and skins shall be subjected to disinfection by one of the following methods:

(*a*) By immersion for not less than 20 hours in a solution containing 2 per cent absolute hydrochloric acid (hydrogen chlorid) and 10 per cent sodium chlorid.

(*b*) By immersion for not less than 40 hours in a solution containing 1 per cent absolute hydrochloric acid (hydrogen chlorid) and 10 per cent sodium chlorid.

(*c*) By immersion for not less than 24 hours in a solution containing 1 per cent formic acid, and mercuric chlorid in the proportion of 1 part to 2,500 parts of the solution. Hides or skins treated by this process shall be held for two weeks following the treatment before neutralization.

(*d*) By immersion for not less than 48 hours in a 1 to 1,000 bichlorid of mercury solution.

(*e*) By immersion for not less than 6 days in a 1 to 5,000 bichlorid of mercury solution, plus not less than 5 days in lime of the usual strength for de-hairing.

Or, in lieu of disinfection by one of the foregoing mentioned processes, the effluent shall be subjected to treatment by one of the following methods:

(*f*) Heat the effluent from soak vats, mill drums, breaking machines, or other similar equipment to a temperature of 100° C. (212° F.) and maintain at that temperature for at least one minute.

(*g*) Treat the effluent from soak vats, mill drums, breaking machines, and other similar equipment with chlorin in such manner and in such

amount (not less than 250 parts per million) as to secure efficient disinfection.

(*h*) Subject the effluent from soak vats, mill drums, breaking machines, and other similar equipment to filtration, the effluent from the filters to be treated with chlorin in sufficient amount and in such manner as to secure efficient disinfection: *Provided, however,* That in this method of treatment the sludge which collects on the filters shall be subjected to disinfection by heating at a temperature of not less than 100° C. (212° F.) for not less than 15 minutes.

(*i*) Treat the effluent from soak vats, mill drums, breaking machines, and other similar equipment with 50 parts of chlorin per million parts of effluent and heat at not less than 80° C. (176° F.) for not less than 30 minutes.

(*j*) In the case of sheepskins and goatskins, until further notice, by immersion for not less than 12 hours in a solution of milk of lime containing the equivalent of 5 per cent of calcium oxid (CaO).

### III. DISINFECTION OF GLUE STOCK

All fleshings, hide cuttings, and parings or glue stock shall be moved from the port of entry to an establishment having proper facilities for the sanitary control and disinfection of such materials, in cars or approved containers sealed with either Department of Agriculture or customs seals, and upon arrival at the establishment, disinfected before removal therefrom by one of the following methods:

1. By heating in water at a temperature of 100° C. (212° F.) for not less than 15 minutes, or by heating in water at a temperature of not less than 82° C. (180° F.) for not less than four hours.
2. By soaking in milk of lime or lime paste for not less than 24 hours.
3. By soaking in water containing not less than 2 per cent of absolute hydrochloric acid for not less than 20 hours.
4. By soaking in water containing not less than 1 per cent of absolute hydrochloric acid for not less than 40 hours.

### IV. DISINFECTION OF BONES

1. All horn pith and porous bones classed as glue stock must be moved from the port of entry to an establishment having proper facilities for their sanitary control and disinfection, in cars or approved containers sealed with either Department of Agriculture or customs seals, and, upon arrival at the establishment, disinfected before removal therefrom as provided for glue stock.
2. Bones with pieces of hide or tendons attached and all other bones not otherwise provided for shall be moved from the port of entry to an establishment having proper facilities for their sanitary control and disinfection, in cars or approved containers sealed with either Department of Agriculture or customs seals, and upon arrival at the establishment, disinfected before removal therefrom by one of the following methods:

(*a*) By heating in water at a temperature of 100° C. (212° F.) for not less than 15 minutes.

(*b*) By heating in water at a temperature of not less than 82° C. (180° F.) for not less than four hours.

### V. DISINFECTION OF HOOFS AND HORNS

Hoofs and horns shall be moved from the port of entry to an establishment having proper facilities for the sanitary control and disinfection of such materials, in cars or approved containers sealed with either Department of Agriculture or customs seals, and disinfected before removal from the establishment by heating in water at a temperature of not less than 74° C. (165° F.) for not less than 15 minutes. Bones removed from

horns and hoofs that are required to be disinfected shall be handled as provided for glue stock.

VI. DISINFECTION OF CONTAINERS OF GLUE STOCK, BONES, HOOFS, AND HORNS

Containers of glue stock, bones, hoofs and horns, which under the provisions of Regulations III and IV of Joint Order No. 2, are required to be disinfected, shall be handled as follows:

(*a*) The containers shall be burned; or

(*b*) The containers shall be subjected to moist heat at a temperature not less than 100° C. (212° F.) for not less than 15 minutes.

VII. DISINFECTION OF HAY, STRAW, ETC.

Hay, straw or similar materials shall be placed in a compartment made tight by sealing all crevices therein and then subjected to treatment with formaldehyde gas applied as follows:

The formaldehyde gas shall be generated from solutions of formaldehyde containing not less than 37 per cent actual formaldehyde by pouring the formaldehyde solution onto pulverized potassium permanganate, the formaldehyde solution and the potassium permanganate being employed in the proportion of 20 ounces of formaldehyde solution by weight and 16⅔ ounces of potassium permanganate by weight to each 1,000 cubic feet of space in the compartment to be disinfected. Bales of hay, straw, or other material shall be piled in block so that not more than 6 inches of any surface of the bale is in contact with another bale, or if deemed necessary by the inspector, the bales shall be broken and the straw or hay loosened, so that a satisfactory penetration of the formaldehyde gas may be obtained. The disinfection with formaldehyde gas shall be carried out in compartments in which the temperature is not less than 65° F.

J. R. Mohler,
*Chief of Bureau of Animal Industry.*

**Hide structure.**—Although the skins of the various animals seem at first glance to have little in common, they present, on closer examination, much similarity of structure. The difference in texture and thickness, on the other hand, makes their practical application vary greatly. The skins of lizards, alligators, fish, and serpents differ from those of higher animals in that the epidermis becomes harder and forms scales. Figures 34 and 35 show cross-sections of hide.

The skin is not merely a covering for the animal, it is at the same time the seat of the organs of sense and of certain important secretions. It consists of two principal layers, the epidermis (*epithelium, cuticle*) and the corium (*derma, cutis,* or true skin). The epidermis is very thin as compared with the true skin which it covers, and is entirely removed preparatory to tanning; it nevertheless possesses important functions. Its inner mucous layer, which rests upon the true skin, is soft

and composed of living nucleated cells, which multiply by division and form cell-walls of *keratin*. These are elongated in the deeper layers, and gradually become flattened as they approach the surface, where they dry up and form the horny layer which is being constantly worn away, thrown off as dead scales of skin, and renewed from below by the multiplication of the cells.

It is from the epithelial layer that the hair, as well as the sweat and fat-glands, are developed. Each hair is surrounded

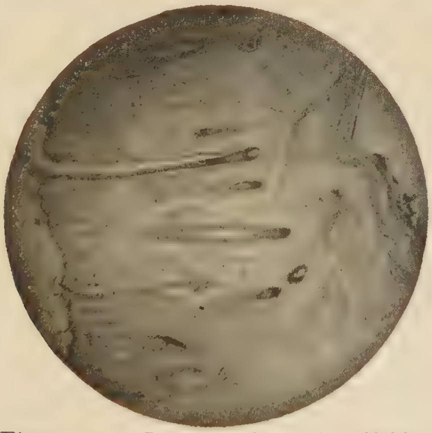

**Figure 34.—Cross-section of calfskin.**

by a sheath continuous with the epidermis, and in which the young hair usually grows as the old one falls out. Near the openings of the hair-sheath upon the surface of the skin the ducts of the sebaceous or fat-glands pass into the sheath, and secrete a sort of oil to lubricate the hair. The base of the hair is a bulb, enclosing the hair papilla, which is a projecting knob of the true skin, and which, by means of the blood-vessels contained in it, supplies nourishment to the hair. The hair bulb is composed of round soft cells, which multiply rapidly, and, pressing upward through the hair-sheath, become hardened, thus increasing the length of the hair.

The process of development of the sudoriferous or sweat-glands is very similar to that of the hair. They consist of more or less convoluted tubes with walls formed of longitudi-

nal fibers of connective tissue from the corium, lined with a single layer of large nucleated cells which secrete the perspiration.

Besides the hair, and hair-sheaths, and the sebaceous and sudoriferous glands, the epidermis layer produces other structures of a horny character, including horns, claws, and nails, which, both chemically and anatomically, are analogous to exaggerated hairs. This is apparent in the quills of the porcupine. The whole of the epidermis, together with the hairs, is separated from the corium by an exceedingly fine membrane

**Figure 35.—Cross-section of cowhide.**

called the "hyaline" or glassy layer. This forms the very thin grain surface of tanned leather, which is of a structure different from the rest of the corium.

The structure of the corium or true skin is quite different from that of the epidermis. It is composed principally of interlacing bundles of fibers known as "connective tissue," and cemented together by a substance more soluble than the fibers themselves. These fiber bundles are loosely interwoven in the middle portion of the skin, but become compact again near the flesh. The outermost layer, just beneath the epidermis, is also very close and compact. The skin is united to the animal by a network of connective tissue (*panniculus adiposus*),

which is frequently full of fat cells and is then called "adipose tissue." This portion, together with some actual flesh, is removed in the process of fleshing.

Ordinarily, the corium or true skin is the only portion used for leather. To obtain it in a suitable condition for the various tanning processes, the hair or wool, together with the epithelium, must be completely removed without damaging the skin itself; and special care must be taken that the grain, or portion next the epidermis, does not suffer injury during the

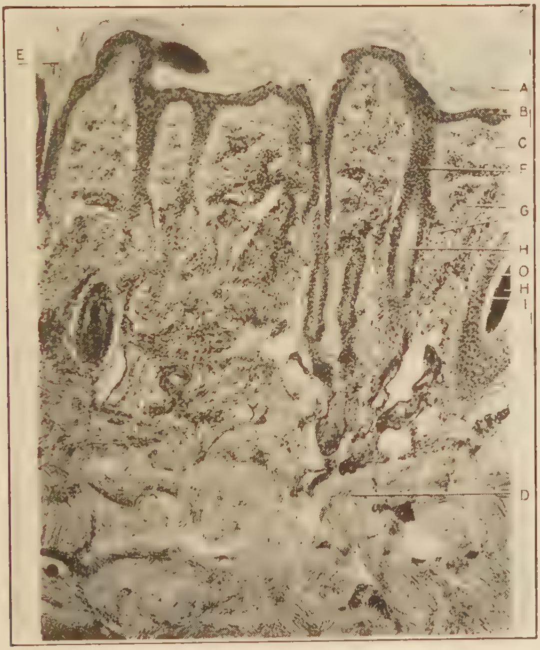


**Figure 36.—Cross-section of calfskin. (a) Corneous layer, (b) malpighian layer, (c) papillary layer, (d) reticular layer, (e) hair shaft, (f) hair follicle, (g) sebaceous gland, (h) hair, (i) inner root-sheath, (o) outer root-sheath.**

treatment. Figure 36 shows a cross-section of a calfskin five weeks old, prepared by Geo. D. Rosenthal.

Samples were taken from various parts of the skin, which on analysis gave the following results:

| *Constituent* | *Belly, per cent* | *Butt, per cent* | *Shoulder, per cent* |
|---|---|---|---|
| Coagulable protein | 4.30 | 4.14 | 5.16 |
| Elastin | 19.43 | 12.31 | 16.74 |
| Mucoid | 1.24 | 4.81 | 2.29 |
| Collagen | 51.46 | 58.83 | 39.66 |
| Keratin | 25.73 | 19.91 | 36.15 |

A very exhaustive study of hide structure was conducted by Dr. Rosenthal, the result of which appears in the 1917 volume of the American Leather Chemists' Association.

**Conservation of skin substance.**—It must appear evident to anyone engaged in the hide and skin business that there is continual loss of substance and depreciation of value in a skin from the moment it is taken off the animal until it is finally converted into leather. The principal reason for this loss is the presence of liquefying bacteria, which bring the gelatine of the skin into solution. The conservation of this material is of vital interest to the tanner, and should also demand the attention of the skin collector and dealer. With this end in view, experiments were conducted for a number of years to discover some inexpensive method of conserving the substance of skins, especially calfskins, without any detrimental effect.

Of all the materials tested, zinc chloride has been found to prevent this liquefaction best, and consequent loss and deterioration without producing any results, visible either in the skin or in the finished leather, that are in any way objectionable.

*Zinc chloride.*—The method of using zinc chloride, which has given the most satisfactory results, is as follows: The fresh skins are first salted in clean, coarse salt for the purpose of withdrawing the blood from them, and are allowed to remain in a low, narrow pile for 24 to 48 hours. They are shaken out of this first salt, which is taken to the refuse pile and thereafter used only for salting the trimmings, and placed in a pack, and to the salt which is used for this second salting,

zinc chloride is added. For convenience, a stock solution is made of 1 lb. of zinc chloride to 1 gallon of water. To a barrel of water, add 1 pint of this solution, and stir thoroughly. The salt intended for the second salting is sprinkled with this zinc chloride solution until a quantity, taken in the hands and pressed, oozes moisture. The salt, treated as above, is thrown on the skins in the usual way. Fresh skins treated in this manner lose practically no gelatine and remain fresh and clean as long as skins are ordinarily kept. The treatment is also valuable in conserving skins that are shipped in. In a case where skins show a tendency to hair-slipping or have become heated, it is advisable to dip them first into a solution of the zinc chloride made by adding 1 pint of the stock liquor to a barrel of water, and salting as directed for the second salt. The results obtained from handling hair-slipped skins in this manner are remarkable. The zinc chloride instantly checks the liquefaction of the bacteria, and the leather produced from the skins is the equal of that made from perfect ones. Comparative experiments with cold-storage methods have also been made. One lot of skins was kept at a temperature of 30° F., another at 0° F.; at the same time, skins were put in pack by the zinc chloride method, and all were held for one year. Those treated in zinc chloride were in every way equal to those kept in cold storage; and the leather produced from the zinc-chloride treated skins was equal to that made from strictly fresh stock.

A general following-up of the above suggestions will do much toward conserving the most valuable constituent of the raw skin. The method is not an expensive one, zinc chloride costing only about 30 cents a pound.

*Formaldehyde.*—The antiseptic and germicidal action of this substance has long been known in medicine and found of practical use, and its application for the preservation or disinfection of raw skins is therefore only natural. With its aid, skins that have already undergone putrefaction may be sterilized, as well as such as it is feared may decompose during interruption of the usual process. To effect this, for each 100

parts of the soak water, take 2 parts of 40 per cent formaldehyde, and use this solution for 6 to 8 days, when it should be strengthened by the addition of a further 2 parts of formaldehyde. Dried skins should be merely soaked for 10 minutes in a solution of formaldehyde of 4 per cent strength, after which they should be laid in piles for 12 hours, and finally dried in the air.

In 1902, Roberts, of Buenos Aires, patented a process by which skins were subjected to the action of antiseptic gas—that is, formaldehyde—for a time in order to preserve them. The Conservadore Mercantile Co. of that city, according to this patent, submitted skins after flaying and before salting to the action of formaldehyde vapors in closed chambers. This destroyed the putrefactive elements which were likely to be present in the skins and sterilized them for a certain time; finally the skins were salted and dried out.

Salting by itself does not sterilize skins permanently; it can only retard and diminish the development and the activity of the putrefactive organisms. The damage known as salt stains is said by some investigators to be caused by micro-organisms which resist the action of salt, and it may be presumed that a treatment with formaldehyde would greatly reduce this form of damage. Also, for skins which are preserved by means of drying, formaldehyde may be of excellent service, the goods not being exposed to the risk of decomposition setting in during drying. Moreover, the pungent odor of the formaldehyde repels flies and other insects, which, under other circumstances, are attracted to the skins during the drying process, and thus the presence of larvae in the goods is very likely prevented. Finally, it is possible by this means to disinfect the skins from carrying disease germs, especially from places which are often subject to this sort of danger. Complete disinfection by means of formaldehyde entails a very strong action, and this causes several difficulties in the work of soaking, liming, etc., which are nevertheless surmountable. In any case, it is only recommended that this process be employed for skins which have undergone slight putrefaction, and for

those in which mere salting would not suffice for perfect preservation. The strength of the solution should never exceed 5 per cent, as otherwise the skin substance will be greatly hardened. If the skins are to be salted, they should not be treated, previous to the salting, with a solution of formaldehyde, because they would absorb too much water, for the removal of which an excessive quantity of salt would be required. It is therefore necessary in this case to use formaldehyde in the gaseous form and not as a solution.

# CHAPTER II

## SOAKING

THE processes that precede the actual tanning or conversion of hides into leather are about the same for all classes, whether the tannage be chrome or vegetable. The object of these processes is to bring the hide to the natural soft condition it

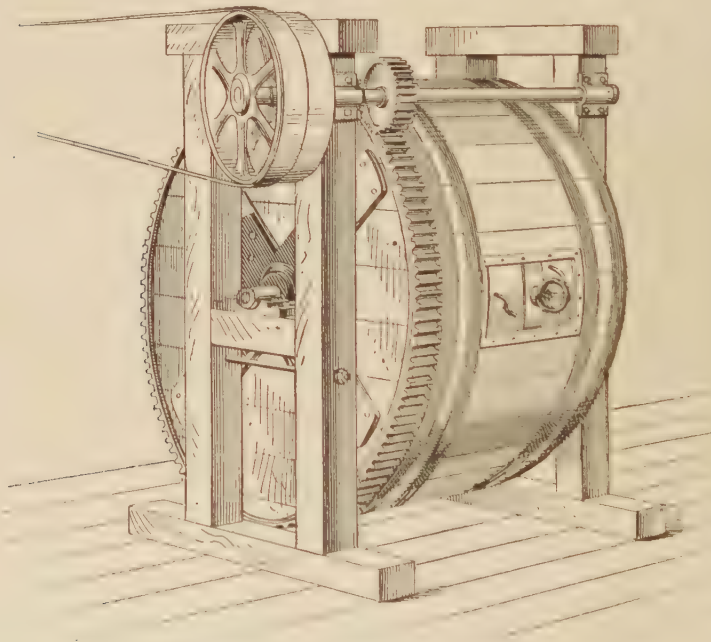

Figure 37.—Pin-mill, wash-wheel, or drum for washing fresh hides.

is in when removed from the animal's back, and in addition, to remove the blood, manure, dirt, and salt.

**Fresh or market hides.**—This grade of hides, after having been trimmed, simply requires washing to remove the blood and dirt, and is usually accomplished by milling for about a half-hour in cold, running water, using a pin-mill or drum as shown in figure 37.

This treatment is absolutely necessary, as the adhering blood, lymph, and dung, would soon set up putrefaction, with subsequent damage to the stock.

**Green-salted hides.**—The hides are first trimmed—the tails, shanks, and pates being cut off in the hide cellar—and are then soaked. One of the most approved methods of soak-

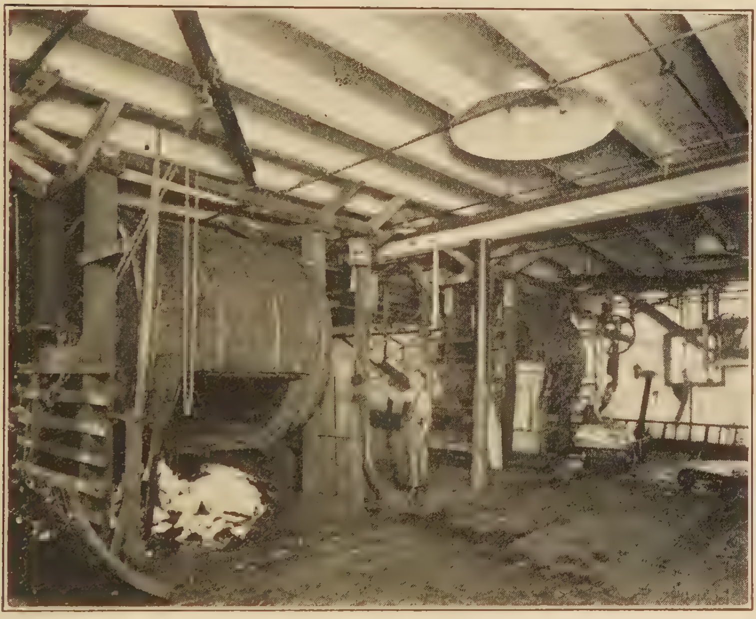

Figure 38.—Washing hides preparatory to soaking.

ing is to hang the hides in the water, which should be soft and clean. If the water is hard, 1 lb. of borax for each 100 gallons of water, dissolved in hot water, should be stirred into it to make it softer, and increase its softening and cleansing powers. The hides should be hung in the water, from tail to head, and left therein for 24 hours; they are then usually taken out and cut into halves or sides. The water in the soak vat is run out and fresh water run in, when the sides are put back and soaked 24 hours longer. Splitting into sides can also be done after the second soaking. The object of the soaking process is to soften the hides and remove the salt,

dung, blood, and dirt adhering to them. It is important that this be done quickly and thoroughly, so that the hides may go into the lime clean and soft, yet retaining their substance intact. Prolonged soaking of salted hides results in a loss of gelatine and in loose and spongy leather. On the other hand, if the hides are not soaked long enough, they do not go into the lime in the right condition, and the grain may have serious defects. It is usually best to change the water once during the process. If the hides are very dirty, two changes are necessary; if only slightly salty and dirty, one change is sufficient. Figure 38 shows the stock out of the wash-wheel and ready for soaking.

No exact rule for soaking can be given, as much depends upon the thickness and condition of the hides and the temperature of the water. Usually, however, ordinary hides are sufficiently soaked by being hung in water 24 hours, then removed and re-soaked another 24 hours. At the end of the soaking process the sides are drained, fleshed, toggled together in a chain, and passed into lime.

A common procedure for green-salted hides is to throw the trimmed stock into fresh water for 24 hours, and then mill for a half-hour in cold running water, when they are fleshed and ready for depilation.

**Dry-salted hides.**—Those that have been dried after salting require a longer soaking to restore the natural soft condition. This is usually accomplished by soaking for 24 hours in water to which 0.2 per cent of caustic soda has been added. The hides are then removed from the soak and milled in running water for a half-hour. They are then cut into sides and returned to the soaks for another day, when they are dry-milled for half an hour, fleshed, and piled-down over night. If not thoroughly soaked, they are returned to the soaks for another day.

**Dry hides.**—Those that are received by the tanner in flint-dry condition require longer soaking and more thorough working in order to get them into the soft, pliable condition which is necessary before they can be fleshed and limed. The follow-

ing method of soaking dry hides usually proves satisfactory: For every 100 gallons of water in the vat, dissolve 1 lb. of sodium sulphide or $\frac{1}{2}$ lb. of caustic soda in hot water, and pour the solution into the water, plunging thoroughly. Put the hides into the water and let them soak 24 hours. At the end of that time take them out of the water, put them into a dry mill, and run them in it 30 minutes; next place them in a pile or piles, covered up, and let them lie 24 hours; then put them back into the water from which they were taken and let them soak 24 hours longer. From this soaking, run the hides in the dry mill for a half-hour; then flesh them. After fleshing, place in clean, cold water over night; then lime them.

**Figure 39.—Fulling stocks.**

Formic acid is sometimes used in soaks to hasten the softening of dry hides, 1 lb. of the acid being added to each 100 gallons of water in the soak vat. The hides are first placed in clean water for a day or two, and then hung in the acidified soak. If they swell excessively, some salt should be added to check the swelling. After the hides have been soaked two or three days, they should be washed and placed in clean water for a few hours and then placed in the lime.

*Stocks.*—In softening flint hides, some tanners resort to the use of the stocks, or kickers, after the preliminary soaking. This mechanical working takes the place of "breaking over," which was formerly accomplished on the beam with a blunt knife. The stocks shown in figure 39 consist of a curved

metal or wooden box, in which two heavy hammers work backward and forward on a cam, thus driving the hides against the walls on either side. The treatment of hides by this method is rather strenuous, and is being replaced by the drum in most tanneries.

*Fleshing.*—In order to facilitate the depilation, hides and skins are usually fleshed before entering the depilating liquor, or may be so treated to assist in the soaking operation. This fleshing consists in removing the excess of flesh or fat on the under side of the hide, and may be accomplished over the beam with a sharp knife or by means of machinery built for the purpose. Figure 40 shows one of the many forms of such

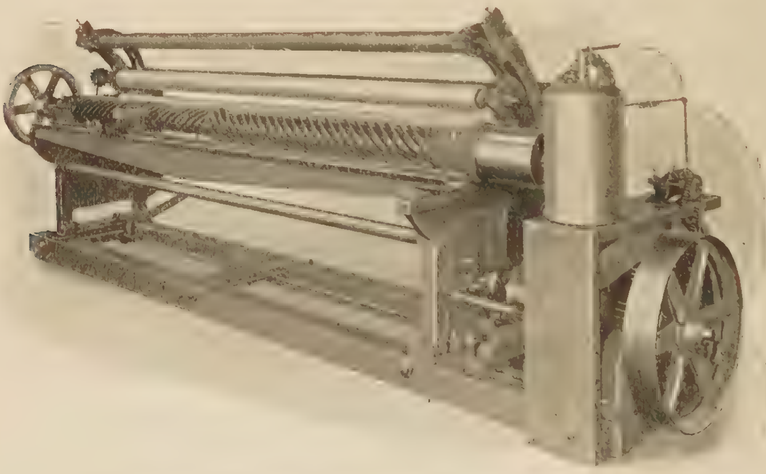

Figure 40.—Turner pneumatic fleshing machine.

machines. It consists essentially of a spiral knife against which the stock is forced by means of a heavy rubber-covered roll. The machine may be adjusted to suit the thickness of the hide and so regulated as to take off a light or deep cut as desired.

*Putrid soaks.*—At one time the use of putrid soaks was very common, but the modern tanner realizes that putrefaction means loss of hide substance; and as he wishes to conserve his hides as much as possible, this wasteful and dangerous

has been almost entirely abandoned. Figure 41 shows hides out of soak, and ready for depilation.

*soaks.*—Various chemical products for hastening been placed upon the market. They are all either aline salts, and have no advantage over sodium dium hydroxide (caustic soda); in fact, expe-

**Figure 41.—Hides ready for depilation.**

rience has shown that of all softening agents the latter is the most satisfactory. For dry hides or kips, a 0.2 per cent solution of this chemical will reduce the time of softening for even flint hide to about two days.

Butyric acid has been suggested as a softening agent, in which case from 3 to 5 oz. are used for each 100 lb. of stock. The advantage derived is that no hide substance is lost. It has never, however, met with popular approval.

*Paddle soaking.*—In pit soaking, the stock is likely to pa at the bottom, and thus be prevented from absorbing uniformly. To overcome this, the hides are drawn a

back. By means of a paddle, the labor involved in handling the stock is obviated, and by simply running the paddle at five-minute intervals twice a day, the hides may be loosened up and the position quickly changed. The use of a paddle is especially advantageous for green-salted or market hides.

**Kips.**—The same methods as applied to hides hold equally good for kips. As this grade of raw stock is used for the same purposes as light hides, the processes employed need no further elaboration.

**Calfskins.**—One of the most important processes through which calfskins are passed before they are tanned into leather consists in soaking, which cleanses and softens them. There are also mechanical and manual operations, such as trimming and fleshing to remove the superfluous and objectionable parts.

*Green-salted skins.*—The soaking of green-salted calfskins should be done in clean, fresh water. As good a method of soaking as any is to shake the skins free from salt, trim off the useless portions, and then put them into the water for 24 hours. The remaining salt and dirt are next removed by washing the skins for 15 minutes with running water. Light skins are then fleshed and put through a liming process. Heavy skins are re-soaked 12 hours and then passed into the lime liquors.

*Dry skins.*—Calfskins that are received at the tannery in a hard, dry condition require thorough softening before they can be limed and unhaired. Caustic soda is an effective softener for such skins. Dissolved and added to the water in which the skins are soaked, it hastens the softening and freshens up the withered fibers and grain; 1 lb. of the alkali is used for each 100 gallons of water in the paddle vat. When the skins have become flexible in the soak they should be taken out and run dry in a drum for half an hour, then put back into the water and soaked 24 hours longer. If they are not perfectly soft at the end of that time, they should be placed in piles over night and then re-soaked in clean water for 24 hours. They ext trimmed and fleshed, and put into the lime.

ce of caustic soda, formic acid and salt may be used

in the soaks. For 100 parts of skins, 5 parts of the acid are used in 1000 parts of water; some salt may advantageously be added. This process takes from 2 to 5 days, according to the substance and condition of the skins. The softening can be hastened by running the skins in a drum, but this should never be done until they are soaked through and fairly pliable in the soak. Upon coming from the acid soak, the skins are fleshed and then put into the lime solutions.

**Sheepskins.**—In the soaking of sheepskins previous to the removal of the wool, the tanner or the wool-puller has not only to consider how the skin can best be brought back to its natural soft condition, but it is also necessary for him to consider the effect the method of soaking adopted may have upon the quality of the wool, since it may be greatly depreciated in value by using the wrong materials to aid the softening of dry sheepskins. In the case of skins received direct from the butcher, all that is required before the depilatory paint is applied is to remove adhering dirt and blood by washing or soaking in water. Simple treatment in this way for a short time has no effect whatever upon the wool, but prolonged soaking may remove much of its peculiar natural fat, which should be retained, as otherwise the wool loses weight, and felting is liable to take place, the luster of the wool being also diminished.

*Fresh skins.*—For fresh skins, the method recommended is to shake them free from adhering salt, and then place them in fresh soft water to remove salt, blood, dirt, etc. They may then, if necessary, be transferred to fresh water for a few hours, after removing any clotted dirt and blood by beating or breaking over the beam. They are then drained and treated for the removal of the wool.

*Dry skins.*—In the soaking of dry pelts, something must be used to shorten the time required for bringing the skins back to the original soft condition. Of the alkalies commonly employed in soaking hair skins, few can be used on sheepskins because of their injurious effect upon the wool. The wool fats are saponified by the alkalies, and removed,

leaving the wool brittle and less elastic, and also injured as regards luster. Caustic soda and sodium sulphide will, in a fairly weak solution, completely dissolve the wool in a few minutes, and therefore cannot be used as softening agents; neither can caustic potash and washing soda be employed. Ammonium carbonate and borax are the alkalies which have the least effect upon wool. If the former is used, the skins, when placed in lime, will become impregnated with calcium carbonate (lime blast) unless the ammonium carbonate is first entirely removed by washing.

Borax may be employed in weak solutions, using 1½ lb. to 100 gallons of water; but in stronger solution it also tends to dissolve the natural grease of the wool. It is not advisable to use acids in the soaks, because of their swelling action on the skin. Sulphurous and formic acids, preferably the latter, may be employed in extremely dilute solutions. These acids are more or less dangerous, however, in the hands of careless and incompetent workmen. Acids are therefore not generally recommended on account of their action on the pelt.

Of the various soaking agents that might be used, sodium bisulphite has been found to give the best results, without injury to either skin or wool. This substance, which is best used in the solid form, is only slightly acid, so that there is no danger of swelling the pelt except in comparatively strong solutions. It is inexpensive, and only a small quantity is required for effective soaking. The wool is improved in color by the bleaching action of the sulphur dioxide present; and its quality, so far as strength, luster, and elasticity are concerned, is in no way impaired. Sodium bisulphite also acts as an antiseptic, preventing the growth of micro-organisms which would produce decomposition of the skin with its consequent loss of skin substance.

According to the Tanner's Year Book, the strength of bisulphite solution that has been found to give the best result in the soaking of sheepskins is 1 lb. of dry commercial sodium bisulphite per 100 gallons of water. The dry skins are placed in this solution, and allowed to remain therein until they are

soft enough for breaking over the beam. After breaking, they are transferred to fresh water to complete the softening, and then treated in the usual way. Very hard skins may be given a second treatment in the solution of sodium bisulphite.

Although bisulphite has an antiseptic action, the subsequent removal of the wool is not prevented, and whatever disadvantages it possesses may be easily overcome.

*Green-salted sheepskins.*—Clean water should be used. In warm weather, 10 or 12 hours is generally sufficient time; but in cold weather the skins may be soaked longer without injury. When the skins have become soft and clean they have been soaked enough. They should then be removed from the water, and thrown over horses or otherwise allowed to drain for several hours, or they may be passed through an extractor and the surplus water removed from them. They should be clean and soft before any depilatory is applied to them.

*Dry sheepskins.*—Sodium bisulphite is of much assistance in soaking dry sheepskins. As stated above, it also acts as an antiseptic and prevents the growth of micro-organisms which would produce decomposition and loss of skin substance. One pound of commercial sodium bisulphite is used for each 100 gallons of water in the soak vat. The dry pelts are placed in the prepared soak, and allowed to remain therein until they are flexible and can be broken over the beam. After they have been either broken over the beam or drummed for a short time, they are put into a fresh soak to complete the softening, and are then treated in the usual way. Very hard skins usually require a second soaking in the sodium bisulphite solution. Ordinary skins become sufficiently soft in 24 hours. It is always advisable to place the skins in fresh water a few hours after they have been softened to remove the sodium bisulphite, as well as the last traces of salt and dirt. It is also good practice to use fresh solutions of the chemical for every two or three packs of skins. The next process is removal of the wool.

**Goatskins.**—It is very important that dried and dry-salted skins should be thoroughly softened and cleansed be-

fore they are put into lime liquors. Dried skins should be soaked separately from dry-salted stock; and to get them softened in the shortest time possible, and the fibers and grain freshened and cleansed, some caustic soda or sodium sulphite should be added to the water, and revolving drums used as soon as the skins become flexible in the water.

*Dried skins.*—The most efficient way to soak dry goat skins is by the use of what is known among tanners as the sulphide soak. This is prepared by adding 1 lb. of sodium sulphide dissolved in hot water, to the water in the soak vat, this quantity being sufficient for 100 gallons of water. If the skins are heavy, and very hard and dirty, 2 lb. of the material should be used. The skins are placed in the prepared soak, and are left therein from one day until the next; they are then drummed in running water for a short time to soften and cleanse them further. From the drum they are placed in a clean soak, containing, like the first, 1 lb. of sodium sulphide or caustic soda for each 100 gallons of water. The next day they are taken out and drummed again in running water. It is good practice then to shut off the water, and run the skins dry in the drum for 15 minutes, after which they should be placed in clear water until the next day. Some skins require longer soaking and more drumming than others. More or less sodium sulphide may be used, according to requirements of the skins, an excess doing no harm. If it is necessary to leave the skins in the last clear soak for some time before liming them, 1 lb. of carbolic acid for each 100 gallons of water should be added to prevent decomposition, the acid being washed out in running water before depilating.

*Dry-salted skins.*—The softening of this class of stock is accomplished by soaking them in a sulphide soak over night, next drumming them in running water, and then re-soaking them in a second sulphide soak for 24 hours. These skins require thorough drumming in running water to rid them of every trace of salt Skins that were pulled off the animal should be cut open after they are soaked and all skins should be trimmed before they are put into lime.

*Sodium bisulphite.*—An efficient soak for dry stock is prepared by adding 1 lb. of sodium bisulphite to every 100 gallons of water in the vat, as already described for sheepskins. The skins are placed in the soak, and when they have become flexible, they are run in a drum and soaked again in a bisulphite liquor, then washed and limed.

**Kangaroo skins.**—On account of the practical exhaustion of kangaroo (wallaby) skins, the manufacture of this type of leather has greatly diminished in recent years. Kangaroo skins are characterized by great suppleness, toughness, and thick grain. The leather is very compact and resists the penetration of moisture, and does not readily crack or peel off. On account of its distinctive qualities it is a splendid shoe material—in a class by itself—and is especially suitable for shoes for tender feet. Excellent leather is made by tanning the skins by a chrome process; also by tanning with quebracho or gambier. Dull-finished kangaroo leather has long been a favorite material for the tops of shoes, and glazed leather for vamps.

*Soaking and softening.*—Kangaroo skins come from Australia, and are received by the tanner in the dry condition. It is necessary to use some chemical in the soaks, such as borax, sodium sulphide, or caustic soda, to hasten the softening, and to bring the goods to as near the natural soft condition as possible. From 1 to 2 lb. of any of these chemicals may be used for every 100 gallons of water in the vat. When the skins have become pliable, they are taken out of the soak and drummed some time, then re-soaked until they are thoroughly softened. The soak readily softens the skins and freshens up the dried and withered grain. The loosened flesh should be removed before the skins are put into lime.

Borax also softens the water and hastens the soaking of the skins, 5 or 6 lb. being sufficient for 1000 gallons of water. Dissolve with hot water; pour the solution into the soak and stir thoroughly; then throw in the skins.

**Pigskins.**—From time immemorial these have been used for many purposes; at the present time they are employed more

extensively than ever. When properly tanned, they are as durable as goatskins, as pliable as calfskins, and present a peculiarly attractive appearance. They are finished in russet and colors, and are used for inner-soling, saddles, traveling-bags, pocketbooks, belts, jewelry cases, bookbindings, sporting goods, shoes, slippers, suspenders, leggings, military equipments, trusses, wall decorations, screens, for upholstering, and for carriage and automobile trimmings. Various ways of tanning them will be described later.

*Washing.*—Pigskins contain a grease that has to be eliminated before they are limed, or the leather will be greasy and hard. After having been scraped out dry before soaking, the skins are washed in a warm solution of sal soda (sodium carbonate). Put about 5 lb of sal soda into a barrel of water heated to 95° F. Put the skins in one at a time, and leave them in long enough to get soaked through, and then put them on the beam and strike them out thoroughly with a dull knife, bearing on hard and forcing out as much of the grease as possible. This should be done two or three times. The skins are then rinsed off in warm water and soaked several hours in cold water before they are de-haired and limed. A great deal of grease can be forced out by thus passing them through the warm solution of sal soda and then working them out on the beam. The skins are next soaked, fleshed, and de-haired.

*De-greasing.*—In recent years, pigskin and other stock containing a large amount of grease, have been de-greased with various solvents. One of the simplest methods consists in running the pickled stock with kerosene, using about 3 gallons for each 100 lb of skins. After running the stock with this material for about one hour, the kerosene is washed out with salt water, finally finishing with a weak pickle solution. A more effective de-greasing mixture is manufactured by the Vacuum Oil Co., and is being used in considerable quantities.

*Krouse Process.*—A process for de-greasing sheep and pigskins has been patented by C. E. Krouse, and consists in treating the dry pickled skins with high test gasoline in specially

built containers. The solvent is pumped into the cylinder containing the skins, where it remains for a definite length of time. The solvent now carrying the removed grease is transferred to a special form of still, where, by distillation, the solvent is removed for further application, while the grease from the skin is recovered, and may be used as crude soap stock or employed for other purposes.

**Furs and hairskins.**—Although the tanner, as a rule, is not interested in the tanning of furs, there are occasions when he does want to preserve the pelt in its natural hair cover.

Soft, green-salted skins to be tanned with the fur or hair on them require but two or three hours' soaking in clean water to become soft and clean. Dry skins are soaked and softened most effectively in water to which borax, caustic soda, or formic acid has been added. A solution of 2 lb. of borax in 100 gallons of water is a suitable soak for dry skins. Well-cured skins can be softened in a soak consisting of 100 gallons of water to which 1 lb. of caustic soda has been added. An excellent soak is also prepared by adding 1 to 2 lb. of formic acid to 100 gallons of water. This is an approved method of soaking, since the acid has antiseptic properties, and will not allow decay to take place. The water used for soaking should always be fresh and clean; and the soaking should be done as quickly as possible, to avoid decomposition and loosening of the hair. When soft and clean, the skins are fleshed, and all lumps of fat and flesh removed. The skins should next be washed in a warm solution of soft soap, which makes the hair and the skin itself clean and free from grease; they are then ready to be tanned.

Another method of preparing the skins is as follows: They are taken in raw condition, and beamed and scraped on the flesh side until they are free from flesh and greasy matter. They are not soaked at first. Softening is done with wet sawdust. Soak some sawdust in water; spread the skins out smooth, flesh side up, and spread the wet sawdust an inch deep on the flesh side, and let them lie until they are softened. In the case of greasy skins it is necessary to soak them in

borax water, and then wash them in warm sal soda solution, omitting the sawdust treatment. When soft, fleshed, and clean, the skins are ready to be tanned.

**Formaldehyde raw stock.**—It often happens that formaldehyde is used as a preservative and disinfectant on skins, but this chemical has a hardening effect on the fibers. For skins partly disinfected by means of formaldehyde this does not present any great difficulty, especially when the skins have been salted, as the salt has penetrated throughout so that they are not hardened at all. For dried skins treated previously with formaldehyde it is necessary to add some activating substance, such as formic acid or sulphurous acid, to the soak water. Naturally, this method of working is not without disadvantage as regards the quality of the glue stock, for it is well known that one cannot obtain as good a quality of such stock; but, of course, the main consideration for the tanner is to obtain good leather, and although the value of the glue stock is not negligible, it is not the principal thing to consider

# CHAPTER III

## DEPILATION

HAVING brought the stock to a soft and perfectly clean condition, as described in the previous chapter, the next step, usually, is the depilation or removal of the hair and epidermis. Accompanying depilation there is generally a swelling action caused by the chemicals used, which makes the fibers separate, and at the same time more or less of the cementing material is dissolved. The natural fats occurring in the hide or skin are also affected during depilation, being converted into soluble and insoluble compounds, which are very largely removed during the working processes.

Hides that have been improperly cured often present what is known as hair-slips; that is, the hair falls out in patches, and is likely to be accompanied by a damaged grain. The cause of this slipping is putrefaction, the stock having become wet in these spots, or perhaps locally overheated during transportation.

**Sweating.**—The oldest method of depilation seems to have been by means of incipient putrefaction, or as it is called, "sweating." The hides were allowed to remain in piles in a warm, damp room until the mucous matter connecting the epidermis with the dermis had decomposed, which thus loosened the hair without injuring the true skin. This method, however, often resulted in damaged stock, and so the process was improved by allowing the hides to hang in a closed, damp room or cellar called a "sweat-pit." Two general methods are employed, known as "cold sweat" and "warm sweat."

*Cold sweat.*—This method is still used in America to some extent, especially for de-hairing dry hides for the manufacture of sole leather. The sweat-pit is a structure usually built above ground, and protected from outside atmospheric influences by means of a double wall between which is a filling of tan bark or other material to prevent loss of heat by radiation.

The temperature of these pits is controlled by means of steam pipes running under the false flooring and a sprinkler system to provide moisture and lower the temperature if necessary. The temperature is maintained at about 70° F. The hides are hung on hooks, each chamber holding a single pack. The sweating usually lasts 4 or 5 days. Near the end of the operation the stock is carefully examined, and those hides showing the first signs of slipping are dropped to the floor in order to retard putrefaction, it being cooler on the floor than higher in the pit. At the end of the process the hides are thrown into lime liquors for a short time in order to remove the slimy feel, and to plump the stock slightly. The value of this process depends upon the fact that the hides are left in a firm condition without any appreciable loss of hide substance, but even if most carefully conducted there is great danger from excessive putrefaction, with resultant damage to the grain.

*Warm sweat.*—The warm-sweat method is very similar to the cold-sweat process, except that a higher temperature, about 80° F., is used, and the time of treatment is somewhat shorter. It is applied more especially to sheepskin and is known as "staling." This process is not employed to any extent in the United States.

**Liming.**—The first chemical method of depilation was that in which slaked lime was employed. Although this material has been used for many years, the methods of application do not differ materially from those in vogue a century or more ago. Lime used for de-hairing must be as free as possible from magnesia, clay, or iron, as these materials not only diminish the lime content, but cause the lime to slake with much more difficulty; and the iron, being insoluble, becomes fixed in the grain, with subsequent production of stains.

*Quicklime.*—The natural source of lime is limestone, in which it occurs in combination with carbon dioxide, and is known chemically as calcium carbonate. There are other natural forms of calcium carbonate, such as chalk and marble. In order to make pure lime or calcium oxide ($CaO$), limestone or chalk is heated in a kiln to a high temperature, when

the carbon dioxide ($CO_2$) is driven off, leaving what is known as quicklime, according to the reaction:

$$CaCO_3+\text{heat}=CaO+CO_2$$

On coming in contact with water, quicklime combines readily with it, forming calcium hydroxide or slaked lime. In doing this, the water should be introduced slowly, and the mass well stirred after each addition. During the slaking a great deal of heat is generated, and the lumps of lime fall to a powder. When properly slaked, the resulting product should assume the appearance of a smooth paste. It is necessary to secure proper slaking, otherwise the unaffected lumps will collect in pockets and cause serious damage to the stock.

*Hydrated lime.*—By the careful addition of just sufficient water to bring about the reaction between lime ($CaO$) and water ($H_2O$), a dry powder may be produced according to the following reaction:

$$CaO+H_2O=Ca(OH)_2$$

This powder is now being largelv used by the tanner, and is known as hydrated lime. The advantage of this material is that it may be kept indefinitely without change, and may be used in the process of depilation without fear of damage to the stock.

Attention should be directed to a statement which is often made, that, owing to the limited solubility of lime in water (1.3 parts per 1,000 at 70° F.), there is no danger of destroying a pack of hides or skins by using an excessive amount. This is misleading. There is probably no danger of destroying the stock, but there is great danger of damaging it by improper lime treatment. That lime can be and is used in various ways is proved by the fact that if we visited 100 tanneries we would find no two plants using the same method of liming. Yet lime is a compound which is only slightly soluble in water, and according to theory, its beneficial effects can only come from what goes into solution; and providing that we always have an excess present, the results should always be the same, no matter how much we may care

to use. This is a case where theory and practice do not coincide.

Many tanners claim that in de-hairing a hide properly it is necessary first to treat the stock with old lime liquors, and gradually bring the hides into fresh lime solutions. There is some foundation for this belief, but there are limitations which must be observed. There is no doubt that old limes do have a softening effect upon dry hides, due to the putrefactive action of the bacteria which they contain, as it has been shown that putrefactive bacteria are present in old limes. That they subsist upon mucous matter between the epidermis and dermis as well as upon the connective material between the fibers has also been shown. But are we sure that they care only for the mucous matter and connective material? We are not safe in assuming that they will attack these materials only, for they will also act upon the fibers or gelatinous matter. Would it not be better to depend upon the soaks for securing the soft condition we desire, and not upon the uncertain action of putrid lime?

It is claimed by some tanners that it is impossible to de-hair with fresh limes, but those who make such a statement have evidently never tried to do so. It is not the intention, however, to try and convert those who are using putrid limes, but rather to give some of the salient points which have developed as the result of a series of tests extending over several years, and which were carried out at the suggestion of the National Association of Tanners. The points that have been paramount in all of these investigations were the determination of weight, measurement, and the condition of the leather obtained when the various well known and commonly used depilating agents were employed. In conducting the experiments, actual working conditions were approximated as closely as possible, and not only was the chemical action noted, but physical changes were studied also.

For the purpose, however, of corroborating the analytical data obtained during the large-scale tests, a series of parallel tests were made in the laboratory on small samples of stock.

The material used in these laboratory tests was shaved free from hair at the start so that this factor of uncertainty might be eliminated.

The first series of large-scale tests was for the purpose of determining the effect of various quantities of lime on the stock as well as the influence of the time of treatment. Both fresh and bettered (strengthened) limes were employed. Several packs of skins were treated with 5 per cent of lime, and at the end of two days showed an increase in weight of about 40 per cent above the trimmed weight. The lime absorbed was about 1.30 per cent. Several packs were then run with 10 per cent of lime, and gave an increase of 50 per cent from the trimmed to the second day out of lime, with an absorption of 3.65 per cent of calcium oxide. One lot treated with 10 per cent of lime gave an increase of 61 per cent, with an absorption of 3.09 per cent of calcium oxide. These results seem to indicate that the larger amount of lime produces a greater increase in weight and causes a greater absorption.

An experiment was made to see if one portion of lime would completely depilate a pack of hides. For this test 10 per cent of lime was added to the stock in the paddle, and without changing was allowed to remain in the same liquor for 10 days. At the end of this time the hair was only partly loosened, it requiring immersion in warm water and considerable work in beaming before the hair was completely removed. Thus an excess of lime was always present, but for some reason the changes which had taken place greatly retarded the depilating effect. An interesting point in connection with this pack was that after 8 days the lime in the solution increased again, showing that it was being drawn from the hides.

In conducting the analytical work, the loss of hide substance was always observed. In all cases where the lime was applied fresh the loss was greater than when the lime was strengthened. This would seem to indicate that new lime has a greater solvent action upon what is called hide substance than an old lime. May it not be possible that in the old limes a protective colloid is formed? To illustrate this point: if a

pack was treated with fresh lime, run for a day, the lime discarded, a fresh lime made up, and so on for a number of days, the loss of hide substance was much greater than where the stock had been strengthened with the same amount of lime. In the pack cited above—being treated for 10 days—it was interesting to note that the amount of dissolved hide substance increased slightly from that found after the second day. From the appearance of the resulting leather, however, there can be no doubt that some action had taken place which had a decided influence upon the character of the product.

The record of pack weights at different stages of liming showed, without exception, that the greatest weight occurred on the fourth day. This was due to the fact that up to that time the lime was being absorbed, but the action was not sufficiently great to cause the hair to drop off. The decrease following the fourth day was on account of the loss of hair. This was shown fairly conclusively in the laboratory tests, where the hair had been eliminated before treatment, these showing no loss after the fourth day. It may be of interest to note a typical increase from samples that were freed from hair and depilated with 5 per cent of lime, which was made fresh each day, and from a series treated with 5 per cent of lime strengthened each day:

| *Days* | *Fresh, increase per cent* | *Strengthened, increase per cent* |
|---|---|---|
| 1 | 42.10 | 42.93 |
| 2 | 2.60 | 2.10 |
| 3 | 4.14 | 4.10 |
| 4 | 1.30 | 1.41 |
| 5 | 1.70 | 1.70 |
| 6 | 0.30 | 3.60 |

These results are of interest, as showing that about 80 per cent of the total increase in weight occurred during the first day. From this it might be assumed that the absorption of lime should give a similar condition. To show, however, what did happen to hides treated with fresh and bettered lime, the following results may be noted:

| | Fresh | | Strengthened | |
|---|---|---|---|---|
| | *Ash* | *Lime in ash* | *Ash* | *Lime in ash* |
| Original dry weight, per cent.... | 0.66 | 33.67 | 0.51 | 32.80 |
| After 1 day.................... | 3.15 | 59.82 | 3.14 | 56.61 |
| After 2 days.................... | 3.30 | 74.45 | 3.71 | 78.98 |
| After 3 days.................... | 4.25 | 76.58 | 4.19 | 80.49 |
| After 4 days.................... | 4.52 | 78.46 | 4.50 | 90.64 |
| After 5 days.................... | 4.21 | 86.69 | 4.81 | 86.07 |
| After 6 days.................... | 5.18 | 82.69 | 4.67 | 84.23 |

The large-scale tests agreed with these laboratory experiments, showing that most of the lime was taken up during the first two days; and both show that the absorption of lime is not wholly responsible for the increase of weight. In other words, the absorption of lime and water do not bear any definite relation to each other. The higher ash in the fresh lime-treated stock would seem to indicate that the fresh lime has a greater solvent action on hide substance than the bettered lime treatment. This is shown by the fact that the ash is higher in the former case, while the lime in the ash is less. This would again indicate that possibly used lime may have a protective colloid effect.

It is generally assumed that during the liming process fat in the hide is saponified, thereby producing a lime soap, and that the formation of this soap tends to open the fibers. That this saponification is not complete is shown by the following results:

| *Fat* | *Fat on dry weight* | |
|---|---|---|
| | *Fresh lime* | *Strengthened lime* |
| Original, per cent.......................... | 5.11 | 5.21 |
| After 1 day.................................. | 1.86 | 2.77 |
| After 2 days.................................. | 2.05 | 1.96 |
| After 3 days.................................. | 1.24 | 1.96 |
| After 4 days.................................. | 3.01 | 4.43 |
| After 5 days.................................. | 1.22 | 1.05 |
| After 6 days.................................. | 1.25 | 2.88 |

Although these results are not very concordant, they do show that practically all of the fat which is saponified becomes so in the first 24 hours. This would perhaps account for the increase in weight of the stock during the same period. It seems fairly safe to say that 75 per cent of the fat was saponified during the first day, and after that practically no

more saponification took place. This is closely related to increase in weight, when it is remembered that practically 80 per cent of the increase in weight took place during the first day.

Many tests were run in the laboratory as well as on a working scale to determine the loss of hide substance occurring in the lime liquors, and the following examples will illustrate what was observed:

| | *Hide substance lost, per cent* | |
|---|---|---|
| *Days* | *Fresh lime* | *Bettered lime* |
| 1 | 0.51 | 0.55 |
| 2 | 0.253 | 0.39 |
| 3 | 0.43 | 0.59 |
| 4 | 0.66 | 0.64 |
| 5 | 0.24 | 0.17 |
| 6 | 0.25 | 0.34 |

These data are of interest from the fact that if we add the first column we will have a loss of hide substance amounting to 2.143 per cent and if the second column is added it would give about the same result. As a matter of fact, the second series of tests are for solutions that had not been changed, and indicate the amount of hide substance which had dissolved during the time the stock was in the solution. In the first series the solution was made up fresh each day; and in the second series the same solution was used continuously, new lime being added to the old solution. These results need some explanation: Do they show again that after a lime has been used for one day some change has taken place which protects the so-called hide substance? It may be possible that the hide substance that has been dissolved changes rapidly into some form which does not respond to the tests applied for hide substance. Similar results have been noted in the working tests, although in these instances a somewhat larger amount of hide substance was observed. The question now arises: What is understood by hide substance? It is fairly well agreed that hide substance does not necessarily mean gelatin, but rather the albuminous material present as connective tissue between the fibers and the layer between the epidermis and true skin.

From the observations noted above it seems fairly safe to assume that the proper manner to apply a straight lime solution would be to put the stock into a lime liquor which is only a few days old at most, and then work up through the series to a fresh lime liquor. The lime that has been used thus for the new pack should then be discarded. This does not mean, of course, that a hard and fast rule can be made which will work for all classes of stock, but it is to be interpreted as being general procedure.

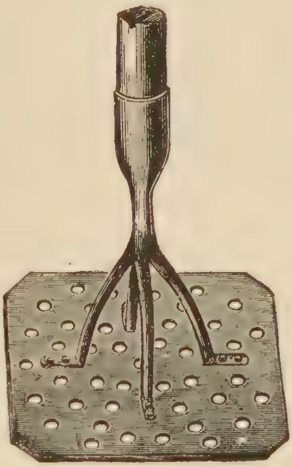

Figure 42.—Lime plunger.

Lime is the most common agent for de-hairing, although it also has disadvantages. In preparing the solution, a quantity of fresh lime is slaked by placing it in a shallow tank similar to that used by builders, and adding sufficient water to moisten it thoroughly. At the end of one or two hours it becomes heated and falls to a powder. Sufficient water is added to form a thick paste which may be kept for several weeks or even months without much change. When required for use, a suitable quantity is dug out, stirred with water to remove rocks, and then run into the pits. It is necessary to provide a surplus of solid lime to replace that taken up by the hide. It is impossible to set any fast rule as to the proper quantity of lime, but a safe margin is 10 lb. for each 100 lb. of hide.

The usual method of liming is to place the hides one at a time into solution, taking care that each hide is well immersed before entering the next one. The hides are taken out ("hauled") each day, the liquor bettered and well "plunged up" with a lime plunger (figure 42) in order to distribute the undissolved lime throughout the pit. They are then thrown back ("set"), care being taken to spread them out fully. In some yards the hides are joined by hooks ("toggled") and reeled

from one pit to another, or to the same pit. Sometimes hides are suspended in the liquor, and the limes are kept in motion by means of a paddle, or by blowing in air. The most com-

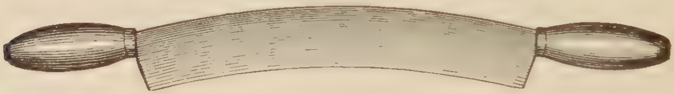

Figure 43.—Beam knife.

mon means, however, of agitating the liquor is by the ordinary paddle-box run at intervals during the day.

The action of lime on the hide is to swell up and soften the epidermis cells, dissolve the mucous layer, and loosen the hair so that on scraping with a blunt knife (figure 43), or work-

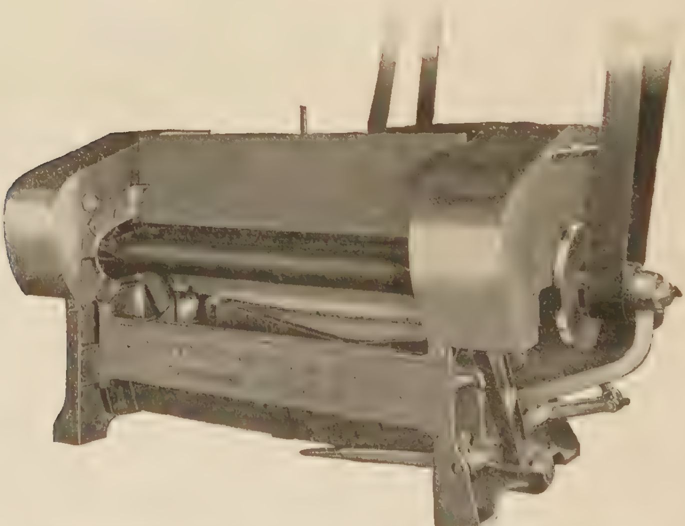

Figure 44.—Whitney model "S" unhairing machine.

ing on the machine (figure 44), both the epidermis and hair are easily removed. The action on the true skin is very vigorous, causing the hide to become plump and swollen, at the same time dissolving the cementing material of the fibers, thus causing them to become split up into finer fibrils. This swelling is probably due to hydrolysis of the albuminous matter

and to formation of a lime soap. Not only does the liming process remove the hair and epidermis, but it is also of value in the re-fleshing process, as it gives the hide a greater firmness, very desirable when working with the knife (figures 45, 46, 47), or on the machine (figure 48). The time of liming varies with the season of the year and with the kind of stock treated; it may run from 3 to 60 days. The age of the lime greatly influences the time of treatment as well as the character of the

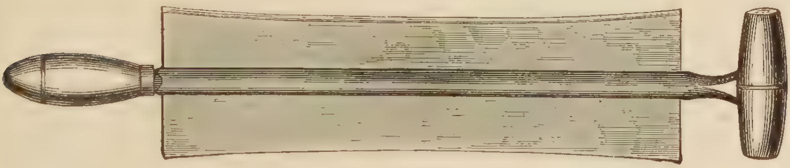

Figure 45.—Broad flesher.

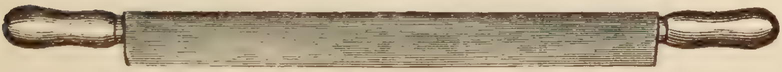

Figure 46.—Spring style fleshing knife.

Figure 47.—Monitor flesher.

finished product. Old limes de-hair much quicker than fresh ones. It is often customary to place the hides in an old lime for several days, or until the hair and epidermis have started to loosen, then change them to a fresh lime which produces the desired plumping of the fibers. Great care, however, must be taken that the limes do not become too old, especially in hot weather, as this condition will very likely produce a transparent swelling of the tissue, with destruction of hide substance.

The period of liming has a marked influence on the finished product. Short liming produces a tight grain, while long liming produces a loose, open grain. The former condition is

necessary in the production of shoe leather, while the latter effect is desirable in glove and fancy leathers.

**Sodium sulphide.**—This material is largely employed as a depilating agent. It may be used alone or in conjunction with other substances if desired. When used alone it has the property of rapidly and completely dissolving the hair, but causes the stock to plump excessively, with the production of a false grain and loss of measurement. It has its advantages as a

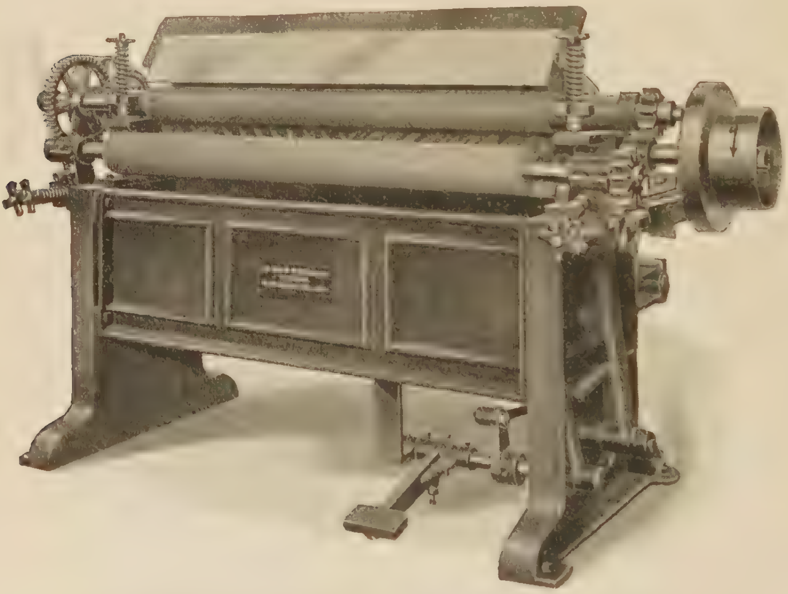

**Figure 48.—Automatic roller fleshing machine.**

time-saver, produces more weight, and a tight grain. The strength of the sodium sulphide solution commonly used is 20° bk. (barkometer) at a temperature of 75° F. The stock is then placed in this liquor, run for 2 hours, allowed to rest over night, run for half an hour, washed, neutralized with sodium bicarbonate, and then again thoroughly washed.

For some classes of leather the sodium sulphide is made into a paste or a heavy liquor and applied to the flesh side. Skins so treated are piled-down over night, and on the following day the hair may be readily removed by hand. This method is

the one commonly employed by wool-pullers and by tanners of other grades of stock carrying valuable hair.

Sodium sulphide mixed with lime materially helps in the removal of fine hairs. For this purpose, about 20 per cent of sulphide on the weight of the lime is sufficient. The sulphide should be added to the lime before slaking. For hydrated lime and sulphide mixture the two should be boiled together. Whenever sodium sulphide is used in conjunction with lime it should be at the start of the de-hairing process. Many tanners, however, use the sulphide after the stock has been limed for several days, but this would seem to be poor policy if its addition is for the purpose of removing fine hairs. This conclusion is based on the fact that sodium sulphide has no solvent action upon hair which has once been treated with lime, no matter how strong the sulphide solution may be made. On the other hand, clean hair will dissolve rapidly even in dilute solutions of sodium sulphide. A good system, and one which has been found to give satisfactory results, is to use a series of three of four pits, adding the sodium sulphide required to the oldest liquor when the new stock enters, the head pit being straight lime liquor. No loss of hair occurs by this treatment, although the stock is free from fine hair and has the appearance of limed stock, except that it has a better grain than is obtained with either sulphide or a long lime treatment.

To determine the effect of the lime and sodium sulphide mixture, several working tests were made with a 5 to 1 combination. The gain in weight from the soaked to the first day out of the liquor was 43.24 per cent; during the second day the gain was 2.45 per cent; while after the third day there was a loss of 0.55 per cent. The loss was caused by the complete slipping of the hair. The amount of lime absorbed increased from day to day, but no more sulphide was taken up after the second day. The laboratory tests conducted along the same lines did not agree very closely with the working tests, owing to the previous removal of hair. Analysis of the hide samples, however, gave results which may show that there

is a reason why lime stock is not so tight-grained as stock treated with sodium sulphide. For example, note the following:

| | New | 1 day | 2 days | 3 days |
|---|---|---|---|---|
| Percentage of fat.......... | 3.55 | 1.19 | 1.57 | 2.11 |
| Percentage of ash.......... | 0.67 | 2.35 | 2.71 | 3.07 |
| Percentage of lime in ash.. | 31.60 | 68.20 | 69.10 | 75.92 |

These records show that the percentage of fat remaining after the treatment was about the same as noted for lime stock. The absorption of lime was somewhat greater after the first day than was observed for straight lime treatment, but on the third day it had increased to that of limed stock. It can be fairly safely assumed that the lime would continue to be absorbed if a longer treatment had been given.

In the working tests with straight sodium sulphide solution, the gain in weight after one day was considerably less than with any of the previous treatments, being about 16.25 per cent. This was due of course to the solvent action of the sulphide on the hair. One pack was treated for four days with the sulphide, but showed little gain after the first day. The hair-free laboratory samples, however, showed a gain of more than 50 per cent after the first day. Analyses of the hide gave 6.70 per cent of fat when new and 1.90 per cent after one day, and 0.44 per cent of ash when new and 0.94 per cent after one day.

It might be expected that stronger alkali would saponify the fat more completely, but the data obtained do not seem to bear this out. Analyses of the liquor showed that the stock at the end of 24 hours had absorbed 0.126 per cent of sodium sulphide and 0.124 per cent of sodium hydroxide (caustic soda).

Among several other methods of depilating which were studied, the one in which a mixture of sodium sulphide and calcium chloride were used should be mentioned. The advantages of this treatment were found to be in the freedom from false grain, complete removal of hair, saving of time, and better measurement than straight sodium sulphide. The method consisted in running the stock in a 20° bk. sulphide

solution, to which had been added one-fourth as much calcium chloride as sulphide.

Sodium sulphide is produced on a commercial scale by fusing together a mixture of sodium sulphate and carbon, the reaction being essentially as follows:

$$Na_2SO_4+2C=Na_2S+CO_2$$

The mass is lixiviated with water and concentrated to crystallization. The product thus obtained is sold to the trade as "crystal sulphide." By carrying the evaporation to the dry state, a solid is obtained which is practically free from water of crystallization, and is known in the trade as "double strength."

Sodium sulphide is also a by-product from the manufacture of other chemicals, barytes, for example.

When used in depilation, sodium sulphide ionizes into two compounds as follows:

$$Na_2S+H_2O=NaHS+NaOH$$

**Arsenic sulphide.**—When the red sulphide of arsenic ($As_2S_2$) is mixed with hot water and added to lime, or mixed with quicklime during slaking, it increases the depilating efficiency of lime. It is especially good for fine leather to which it gives the necessary stretch, softness, and clearness of grain, without the loss of hide substance, and the loosening effect caused by ordinary liming. The amount used varies somewhat, but may be said to run from 0.1 to 0.4 per cent of realgar (arsenic sulphide) and 4 to 6 per cent of lime, reckoned on the weight of the green skins.

**Caustic soda.**—This chemical is produced by the electrolysis of sodium chloride, or common salt. By passing an electric current through a concentrated solution of salt, the water, in decomposing, gives the hydroxyl ion to the sodium and the hydrogen ion to the chlorine, thus:

$$\overset{+}{Na}\ \overset{-}{Ci} + \overset{+}{H}\ \overset{-}{O}\ H > \overset{+}{Na}\ \overset{-}{OH} + \overset{+}{H}\ \overset{-}{Cl}$$

Owing to the fact that the hydrochloric acid is also broken

up by the current, a further decomposition takes place, resulting in the generation of chlorine gas. The final products of electrolysis, therefore, are sodium hydroxide or caustic soda, chlorine, and hydrogen.

When dissolved in water to the amount of 1 lb. per gallon, caustic soda forms a solution which is known as above normal, in which strength it will dissolve the hair very rapidly, but will not plump the stock. By using such a strength, skins or hides may be depilated in the course of half an hour. Such strong solutions are of no interest in practical tanning, as they are difficult to handle and very expensive. A small quantity of caustic soda, however, added to lime, has a decided advantage, as it aids materially in plumping the stock and shortens the time of treatment, and is spoken of as "sharpening the limes."

**Calcium sulphydrate.**—This compound is a powerful depilatory, but is little used on account of its unstable character. It is probably formed to some extent when sodium sulphide or arsenic sulphide is added to lime. It may be produced by passing hydrogen sulphide (a gas) into milk of lime until the latter becomes saturated. This is the substance largely sold as a patent depilatory for removing superfluous growth of hair.

**Arazym.**—It has recently been discovered by Dr. Otto Rohm that hides and skins can be de-haired and bated in one operation by means of "tryptase" in an alkaline solution. This process gives especially good results on goat skins, and as no bating is necessary, the process is meeting with approval, although rather slow in adoption.

**Unhairing.***—When the process of depilation is complete, the skins or hides are removed from the pits and allowed to drain for half an hour or more. They are then placed on the beam, and the hair is removed by means of a blunt knife. Various machines have been devised to remove hair, and these

* Both "unhairing" and "de-hairing" are used in this book, the former when referring to the mechanical operation, and the latter to the chemical process or the removal of hair in general.

have been brought to such perfection that hand work has been almost entirely eliminated. The unhairing machine as shown in figure 44 represents a common type. It is similar in construction to the fleshing machine, but is provided with a blunt knife which works against the grain of the stock.

**Methods of depilation.**—Having discussed the various materials employed for depilation in a general way, let us consider a few methods which are claimed to give satisfactory results:

**Liming hides for upper leather.**—1. Green-salted hides that are intended for soft, supple leather—chrome or vegetable tanned—worked through a liming process according to the following directions, will be found to be sufficiently limed for de-hairing in six days. Exact quantities of lime and sodium sulphide should be used, namely, 8 lb. of the former and 2 lb. of the latter for every 100 lb. of hides.

To start the liming process, slake 1½ lb. of lime for each 100 lb. of stock, add it to the water in the vat, and plunge up well. Reel the chain of hides into the prepared lime, taking care that each side is spread out flat and not rolled, folded, or twisted. After the hides have been 24 hours in this lime, reel them into the second lime, made by adding the same quantity of lime to water that was used in the first lime. Leave the hides in this lime 24 hours. Then make up the third lime the same as the second, and allow the hides to remain in it 24 hours. Reel them into the fourth lime, which should also contain the same quantity of lime, and leave them in it 24 hours. The fifth lime should contain 1 lb. of lime, and the hides should remain therein 24 hours, when they are reeled into the sixth lime, which should contain 1 lb. of lime and 2 lb. of sodium sulphide. This lime should be warmed to 75° F., and the hides left in it 24 hours, when they are reeled into warm water and de-haired after two or three hours. The positions of the hides should be changed every day, and fresh lime used every day, the hides remaining in each lime 24 hours.

After the hides have been de-haired, wash them with running water for 15 minutes; then place them in water at 90°

F., and work them over the beam or on the machine, and then put them into the bating liquor. This process produces very uniform leather. The hair should come off easily and clean. De-hairing out of new lime gives hard, plump hides, a desirable condition for chrome tannage and for splitting out of lime. After de-hairing, the hides can be split, or they may be bated and pickled and then split; or bated, pickled, and tanned, and split after they are tanned.

Although 8 lb. of lime will de-hair 100 lb. of hides, softer leather is obtained by using 10 lb. in 6 limes, starting with 1½ lb., and using 2 lb. each day until the hides reach the fifth lime, which should contain 2½ lb. of lime and 1 lb. of sodium sulphide. Either of these processes produces satisfactory results for chrome or vegetable tanning. If the hides are to be split out of lime, they should be de-haired, put into warm water, and worked by hand over the beam or on the machine, and left in cold water over night to harden for splitting.

2. Sides that are intended for shoe leather and other soft and supple stock may be limed and de-haired with excellent results, according to the following instructions:

By calling the pits A, B, and C, and numbering the packs, the method of procedure may be readily understood. The quantities of lime and sodium sulphide are based on 100 lb. of wet, fleshed hides. The temperature of the limes should be maintained at 70° F. The process is as follows:

*First day:* Pack No. 1 is put into pit A, containing 5 per cent lime and 1 per cent sodium sulphide.

*Second day:* Pack No. 1 is transferred to pit B, containing 5 per cent lime and 1 per cent sodium sulphide; pack No. 2 is put into pit A, once used.

*Third day:* Pack No. 1 is put into pit C, containing 5 per cent lime and 1 per cent sodium sulphide; pack No. 2 is transferred to liquor B, once used; pack No. 3 enters pit A, twice used.

*Fourth day:* Pack No. 1 is removed; pack No. 3 is drawn from A, and new liquor consisting of 5 per cent lime and 1 per cent sodium sulphide is made up with that pit; pack No.

2 is transferred to A; pack No. 3 is put into C, once used; pack No. 4 enters pit B, twice used.

*Fifth day:* Pack No. 2 is removed; pack No. 4 is drawn from B, and a new liquor is prepared as above; pack No. 3 is transferred to B; pack No. 4 is transferred to A, once used; pack No. 5 is put into C, twice used.

*Sixth day:* Pack No. 3 is removed; pack No. 5 is drawn from C, and new liquor prepared; pack No. 4 is transferred to C; pack No. 5 is put into B, once used; pack No. 6 is transferred to A, used twice.

When once started, this cycle can be kept up, and it entails only a small amount of handling of the stock. This method gives a good grain and full feel. On removing the hides from the lime liquor they should be thrown into water at 85° F. for a half-hour, then unhaired on the machine or over the beam. The next process is bating.

**Sodium sulphide process for dry hides.**—The immersion of hides in a solution of sodium sulphide removes the hair quickly, freshens the grain and imparts great toughness to the leather. This is an excellent process for heavy chrome leather for winter and work shoes. The hides should be split into sides, fleshed, and put into cold water over night.

The de-hairing solution is prepared in the following manner: Put 200 lb. of sodium sulphide into a barrel two-thirds full of water. Turn on steam, and boil slowly until the sulphide is dissolved. Let the solution stand until the foreign matter has settled and the liquor is cold, which requires 12 hours, or over night. Only the clear solution should be used.

Put enough water into a vat to cover the sides, and add enough sodium sulphide to make a 6 or 7° bk. liquor. The exact strength, however, is immaterial; the stronger the liquor the sooner the hair is dissolved; but a good rule to follow is to start with a liquor of 6°, which requires about three days to accomplish the desired result. Put the sides, opened out well, into the liquor, and let them remain 24 hours; then haul them out. Plunge the liquor up and put the sides back, for another 24 hours; then haul them out again. Plunge the liquor again,

and return the sides for another 24 hours. At the end of the third day the hair should have been reduced to a slimy mass, which can be easily washed off, leaving the hides clean. Put the hides into a wash-wheel with running water and wash them clean. If there is any hair that does not come off, the sides should be worked on a beam; and if this does not remove the hair, add some fresh sodium sulphide solution to the liquor, and put the hides back into it for another 24 hours. After washing, the hides are limed.

Slake ½ bushel of lime for each 100 sides in the pack, and add the slaked lime to water in a pit, put the de-haired hides into the liquor, and keep them therein two days, handling them each day. A little more lime may be used to make a softer leather. After the sides have been thus limed, wash them in cold water, and then split them into grains and splits, and bate and pickle them.

This process destroys the hair, but makes plump and tough leather. Men who handle the hides through the sulphide process must wear rubber gloves to protect their hands from the caustic material. When hides are split out of the lime the grains are bated, pickled, and tanned; if they are split out of pickle or after tanning, they are bated and pickled whole. Opinions differ in regard to the best time for splitting.

The condition of the flanks and the fineness of the grain depend largely upon how the grains are bated and de-limed.

**Notes on beam-house work.**—In the process of liming hides for sole leather, and other kinds of firm and solid leather, much depends upon the condition of the lime liquors. A new lime has great swelling and plumping effect upon the hides. Such a lime, particularly if caustic soda is added to it, is strongly antiseptic. A short liming in new, sharp liquors is desirable in order that but little hide substance may be dissolved. The plumping effect of such a lime is considerable, while an old lime liquor has a more solvent effect and does not plump the hides so well. Caustic soda in the lime liquor assists in getting the full plumping effect, but it must be used carefully or it will cause rough grain.

Where sodium sulphide is used in the lime liquors, the de-hairing is hastened and the plumping effect of the lime increased; but unless the sulphide is used rather sparingly, the grain is liable to be coarse. An old lime liquor containing considerable sulphide makes leather more pliable than a clear, fresh lime liquor. An old lime dissolves hide substance, which means pliable leather, but the swelling effect of such a lime is less than that of a new lime. For sole leather, therefore, liming should be done in new liquors to get the full plumping effect and to avoid the loss of hide substance.

If pliability is an essential in the leather, the best procedure is to place the hides first in an old lime to get the softening effect, and then place them in a fresh lime where they will be plumped. The more mellow the lime liquors are the greater the flexibility of the leather.

For some leathers, such as harness, fairly fresh limes containing sodium sulphide should be used. Such limes accomplish the swelling and de-hairing rapidly, but do not dissolve enough substance to make the requisite degree of flexibility; and it is therefore advantageous to accomplish the latter effect in the bates. Bacterial bates dissolve considerable substance, and where pliability is desired, such bates should be used, especially when liming has been done in fresh limes.

Soft leather is obtained by somewhat long treatment in mellow limes, followed by thorough bating and rather heavy pickling. This is the usual process for certain grades of upper shoe leather, glove leather, etc. For leather that is to be finished dull, sodium sulphide is preferable in the limes; and for that to be given a fine, glazed finish, red arsenic is best.

*Arsenic sulphide.*—Where sodium sulphide is used in the presence of lime, the chemical reaction produces caustic soda and calcium polysulphide. Being soluble, this caustic soda has a pronounced action in the liming operation. Where arsenic sulphide is used in the limes, the reaction produces calcium polysulphide and insoluble hydrate of arsenic, and consequently differs from the results obtained with sodium sulphide to the extent that the caustic soda may influence the operation.

Arsenical limes have a characteristic action, due to the calcium sulphydrate which forms when red arsenic is added to slaking lime. Sodium sulphide should be dissolved separately and added to the lime, but red arsenic should be mixed with the dry lime and slaked with it, or else added to the lime while it is slaking. Lime should, in every case, be thoroughly slaked and stirred before it is used. Unslaked lumps should never be allowed to pass into the lime liquor, as they are likely to burn the hides. Caustic soda may be added direct to the lime liquor. Its use can be recommended for heavy leather, as it sharpens the lime, but not for light, soft, leather, the latter being benefited most by the use of sodium sulphide or red arsenic. Caustic soda is useful in swelling and plumping the hides quite rapidly, but it does not assist in making soft leather. There is considerable bacterial activity in an old and mellow lime, and such a liquor, on account of its solvent effect, tends to produce a leather that is soft and loose, and has a dull grain. Hides that have been passed through such a lime should therefore be put into a fresh lime to be properly swollen and plumped.

Sun-dried hides should be de-haired with sodium sulphide in the limes, since such a process swells the fibers and freshens up the withered grain more than does lime alone or lime and red arsenic. De-hairing in a strong solution of sodium sulphide and then liming for a few days is another excellent process for dried hides. Soaking in a sulphide soak, supplemented by working in a dry mill, is usually found to be the most satisfactory process which can be used on dry hides for upper harness, and sole leather.

**Liming for thin grain.**—Leather can be made with a thick or a thin grain by certain manipulations in the beam-house. Hides can be so treated that when they are tanned they have a thick, solid grain, this being usually done by using sodium sulphide and de-hairing the hides rapidly. On the other hand by treating in only clean, white lime, the grain can be made soft and flexible, and so thin that when the leather is split after it is tanned the grains have consid-

erable substance and strength, even when the hides are split unusually thin.

By shaving the hides green, liming them for 8 days, bating them until they are soft and low, and stirring them easily in

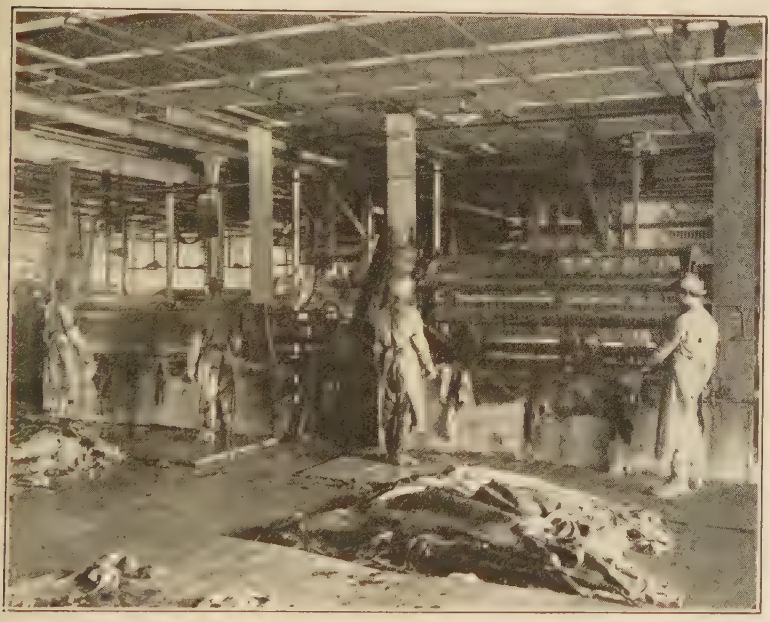

Figure 49.—Unhairing on the Leidgen machine.

the tan liquors, a thin grain is obtained. One process accomplishing this is carried out as follows:

The hides are first soaked 24 hours in clean water; they are then fleshed and re-soaked 12 hours longer, drained, and passed into the first lime. This lime is prepared by using 1 lb. of lime in sufficient water for 100 lb. of hides. The hides remain in this lime 24 hours, and are then hauled out and the lime is strengthened by adding another pound of lime. The hides are put back for 24 hours longer, then hauled out and put into the second pit. The third lime liquor should contain 2 lb. of fresh slaked lime for each 100 lb. of hides in the pack. At the end of 24 hours the hides should be hauled out and placed in the third lime, prepared the same way as the

second lime. Twenty-four hours later the hides should go into the fourth lime, which should be a little stronger in lime than the preceding liquor. At the end of 8 or 9 days the hides should be in condition to be de-haired. After they have

Figure 50.—Hand fleshing on the beam.

been de-haired, put them into water warmed to 85° F. for 6 or 7 hours; then work them over the beam by hand, and get them as clean as possible.

**Liming for sole leather.**—In liming this grade of stock, the hides are first treated with a mixture of 10 per cent of hydrated lime and 2 per cent of sodium sulphide, and left in the liquor for one day. On the second day they are transferred to another paddle or pit containing 10 per cent of hydrated lime and 1 per cent of sodium sulphide. On the third day, the hides are changed to straight lime liquor containing 10 per cent of the weight of the stock. On the fourth and fifth days they are also changed to straight lime. On the sixth day they are thrown into the warm pool for half an

hour, after which they are ready for de-hairing. On removal from the warm pool, the sides are placed on a table, spotted for white hair, and then unhaired on the machine, (figure 49). Following the unhairing on the machine, the hides are re-

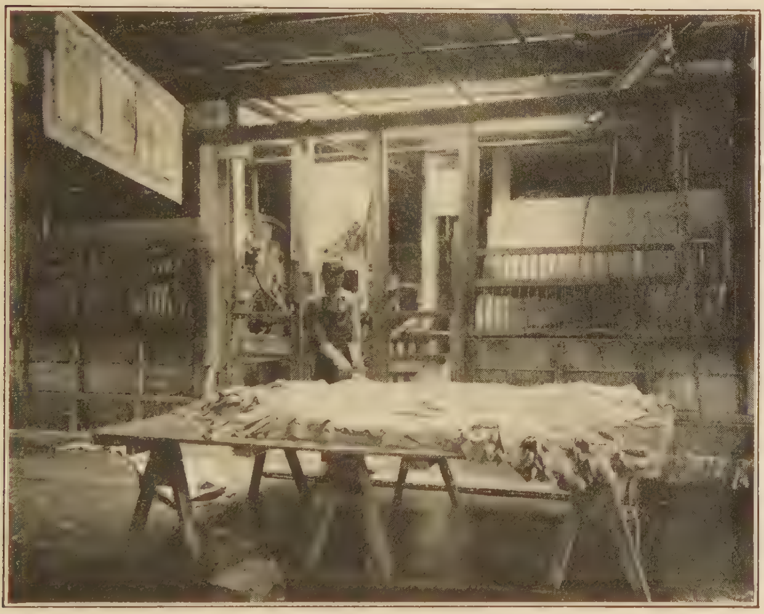

**Figure 51.—Inspection for fine hairs.**

fleshed on the machine and then hand fleshed on the beam, (figure 50). They are then inspected for fine hairs as shown in figure 51.

**Sulphide process for sides, kips, or calf.**—The well-soaked and washed stock is put into a paddle containing a 20° bk. solution of sodium sulphide at 70° F. The paddle is run for about 2 hours, when the wheel is stopped, and after that run for 5 minutes each hour The stock is kept in the liquor over night, and turned from time to time during the morning. At about noon, the plug is drawn and the spent liquor let out. The paddle is filled with water and run for half an hour. One per cent of sodium bicarbonate is now added. and the wheel is turned for one hour. Fresh water is

next turned on, and the stock is washed for 3 hours. By this time it should be fairly free from sulphide and in a fallen condition. It is then removed from the paddle, and may be bated and pickled as desired.

*Sodium sulphide and calcium chloride on sides and kips.*—Put into the paddle a weighed amount of sodium sulphide sufficient to make a 20° bk. solution. To this solution add one-fourth as much calcium chloride as sodium sulphide used. Raise the temperature of the solution to about 80° F., and then introduce the stock and run at intervals during the day. Allow the stock to remain in the liquor over night, and at the end of 24 hours wash thoroughly in running water for 1 hour. The stock is then neutralized with 2 per cent of sodium bisulphite, running 1 hour in the liquor. The hides or skins are then thoroughly washed in running water, and are ready for the bate.

**Liming of calfskins.**—After calfskins have been soaked and fleshed, they are put through the lime process. For light skins, liming according to the following directions will be found satisfactory in every respect, the skins being brought into condition for de-hairing in 4 or 5 days. For each 100 lb. of skins 5 lb. of lime is used. It is thoroughly slaked and added to the water in the paddle, and 1 lb. of sodium sulphide, dissolved in hot water, is added. The temperature of the liquor is then raised to 75° F.; the skins are thrown in, and the paddle is run at intervals during the day. The next morning, 5 lb. of lime and 1 lb. of sodium sulphide are poured into the liquor; and the skins, which have previously been hauled out, are put back and left in the liquor with occasional stirring 1 or 2 days longer, when the liquor is again strengthened in the same manner as before and warmed to 75° F., this temperature being maintained during the entire process. At the end of 4 days, the skins should de-hair easily, but it does no harm to leave them in the lime a day longer. Heavy skins require another addition of sodium sulphide and lime, and 2 days more or longer in the liquor. The hair should come off easily without straining the grain. When taken out of the

lime liquor, the skins should be thrown into water at 85° F. for a half-hour, then de-haired carefully, washed and put into the bate.

Another satisfactory process of liming calfskins is carried out as follows: the quantities of lime and sodium sulphide being for 100 lb. of skins. The first solution contains 2 lb. of lime, and the skins are left in for 24 hours. The second solution contains 2 lb. of lime and 1 lb. of sodium sulphide, the skins also remaining therein 24 hours. The next day they are hauled out, the liquor is thoroughly plunged, and the skins are put back for 24 hours. The third lime is made up of the same quantity of lime and sodium sulphide as the second lime, and the skins are left therein 24 hours. The fourth lime contains 2 lb. of lime, and is warmed to 80° F. The skins remain in this for 24 hours, and then are put into clean water at 85° F. After having been in this water for 2 or 3 hours, they are de-haired.

**Lime and arsenic.**—In this liming process, lime and red arsenic are used, and the skins are brought into good condition for chrome or vegetable tanning. To start with, use a new solution made by adding 2 lb. of lime, well slaked, to the requisite volume of water in the paddle. Leave the skins in this lime 24 hours. On the second day, haul them out, plunge the liquor, and put the skins back. On the third day, add 2 lb. of lime, stirring the goods at intervals during the day. On the fourth day, haul the skins out, and after plunging the lime, put them back. On the fifth day, add 3 lb. of lime, well slaked, and 1½ lb. of red arsenic, slaked with the lime. On the sixth day, simply haul the skins out and put them back, plunging the liquor well. On the seventh day, add 3 lb. of lime and 1½ lb. of red arsenic, and warm the liquor with steam to 75° F. On the eighth day, haul the skins out of the lime, warm the liquor as before, and put the skins back. The hair should come off easily on the ninth day. After the hair has been removed, the skins should be washed in warm water, re-fleshed, and all the fine hair worked out. They are then washed and bated.

Red arsenic keeps the grain smooth and the skins flat; it also produces fine grain on the leather which takes a fine glazed finish. The lime and red arsenic should be mixed together dry and slaked with hot water. Place the limed skins in warm water containing 12 oz. of borax to 100 gallons of water to soften the grain and dissolve the lime on the surface, so that the fine hairs and waste matter will come out readily when the skins are worked. The quantities of lime and arsenic in the foregoing process are for 100 lb. of skins.

The use of a paste of lime and red arsenic is not customary among tanners of calfskins; yet such a method of de-hairing, followed by liming for a few days, gives smooth, soft skins with fine grain and texture. The paste of lime and red arsenic should be prepared a day or two before using. Mix 50 lb. of lime and 2 lb. of the arsenic, and slake together with hot water. The mixture should be stirred while it is slaking, and enough water added to make it as thick as paint. The skins are spread out on the floor or a table, and the prepared mixture is spread upon the flesh side with a brush, the skins folded down the middle lengthwise, and placed in piles in a vat. When the vat is about three-quarters full, some boards loaded with stones are placed on the skins, and the vat is filled with water. After 5 or 6 days the skins are taken out of the vat, washed, and de-haired. Some skins require from 6 to 8 days before they can be de-haired. The next process is liming.

For each 100 lb. of skins in the lot, use 14 lb. of lime and 5 lb. of red arsenic; 1 or 2 lb. more of lime and a little more arsenic may be used for soft leather. The skins are limed from 3 to 7 days, according to their thickness, being stirred by the paddles 3 to 4 hours each day. Having been thus limed, the skins are next washed and bated.

The following method of liming with lime and sodium sulphide, described under side leathers, produces good grain and full feel without much loss of skin substance, so it is a good process to use in preparing calfskins, kips, etc., for chrome tannage. When once started, the movement described entails

only a small amount of handling of the stock. Calfskins having a heavy neck are split on the checking machine shown in figure 52.

**Liming of goatskins.**—After softening, as shown in figure

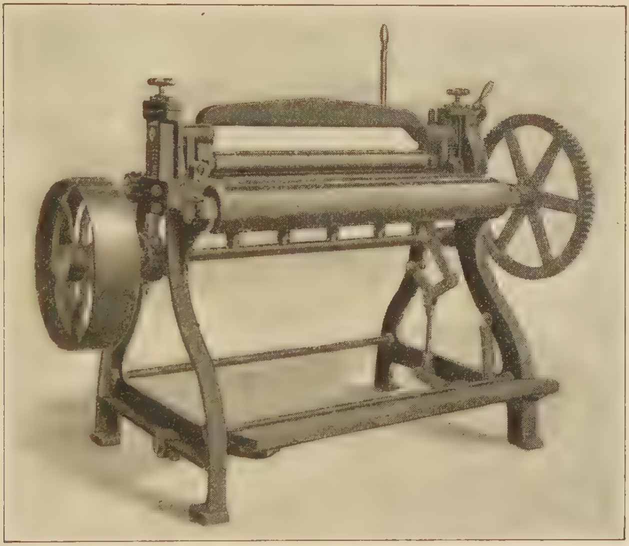

**Figure 52.—Checking machine, used for splitting necks on calfskins.**

53, a liming process in which sodium sulphide is used, produces first-class results and does not make fine-hairing necessary, is carried out as follows:

For 100 lb. of skins, 3 lb. of lime and $1\frac{1}{2}$ lb. of sodium sulphide are used as a first lime, the skins remaining in it one day. They are then hauled out and the same quantities of lime and sodium sulphide are added. On the third day the skins are hauled out, and put back after the lime has been plunged. On the fourth day the lime is strengthened and warmed to 80° F.; the skins are put back until the sixth day, when they are de-haired, washed, and bated. If they do not de-hair easily, the liquor should be warmed and the skins left in a day or two longer.

Liming with lime and red arsenic produces fine-grained

leather. To start with, the goods are put into a weak liquor, containing 2 per cent of lime, calculated on the weight of the raw stock. After being in this for a day they are hauled out and put back. On the third day, 2 per cent more of lime,

Figure 53.—A typical beam-house of a goatskin tannery.

well slaked, should be given. On the fourth day the skins are hauled out, the liquor is plunged, and the goods are put back. To strengthen the lime on the fifth day, 3 per cent of lime and 2 per cent of red arsenic, slaked together, should be added; and on the sixth day the goods are hauled out and put back, so that those that were on top before are now on the bottom, and those previously at the bottom are on top. On the seventh day 3 per cent of lime and 2 per cent of red arsenic are added. On the eighth day it is advisable to haul the skins out and warm the liquor to 80° F., then put the goods back, and after leaving them one day longer de-hair them. They are next washed 10 minutes in cold water, re-fleshed, worked for fine hairs, and then bated. The exact quantity of lime to use and the number of days to leave the goods in the lime depends

upon their thickness, heavy goods requiring longer liming than light, thin ones. For the preparation of glazed kid, a fairly long liming is required, usually 12 to 15 days. Either lime and arsenic or lime and sulphide may be employed. After the goods have been de-haired, they are re-fleshed, and passed into the bating process.

*Combination process.*—Run 700 gallons of water into a paddle, and add 100 lb. of sodium sulphide crystals dissolved in hot water. Put a pack of skins into this liquor, and leave them until the hair is dissolved, when they are ready to be limed. The liquor swells the skins and dissolves the hair. The next process is liming. Slake 100 lb. of lime, and add 700 gallons of water. Put the de-haired skins into this liquor, and turn them in it 2 or 3 days, then wash them and scrape the flesh side again. Some of the hairs which may be broken on the grain should be removed from the flesh side, and much of the remaining grease will come out at the same time. The skins are then in condition to be bated.

**Depilatory compounds for wool skins and hairskins.**—The present methods of removing wool from sheepskins and the hair from goatskins and other light skins are considerably different from the old-time process of sweating and liming, the latter having been replaced by the method of painting mixtures on the flesh side, of which lime is mainly the base. These usually contain lime and some sulphide, such as sodium sulphide or arsenic sulphide (red arsenic). By mixing lime with either of these substances, and adding water, a paste is obtained which, when applied to the flesh side of the skins, causes the hair or the wool to be loosened in a few hours. Methods of mixing lime and sulphides vary. It is usually considered good practice either to slake the lime with a solution of sodium sulphide, or mix the lime with the sulphide first, and then slake with water; or in the case of arsenic sulphide and lime, to place the two in alternate layers and then slake. The high temperature caused by the slaking of the lime produces a reaction between the sulphide and the lime, so that hair-removing compounds are formed

As a type of method, the following, which has been recommended by the Light Leather Trades Federation of Great Britain, may be given ($7\frac{1}{2}$ lb. of sodium sulphide crystals to every 40 lb. of dry lime, are the desired proportions for all skins):

Take the 40 lb. of lime, slake in 9 gallons of water, and allow to stand for three days, so that all the hard substances are well slaked. Pass the slaked lime through a sieve with 10 meshes to the lineal inch. Dissolve the $7\frac{1}{2}$ lb. of sodium sulphide in 1 gallon of water, and add the sulphide solution to the lime, mixing well. The mixture is then ready for painting the skins, which should be pulled not later than the next day. As they are pulled they should be washed in clean water before they are put into weak lime.

A suitable depilatory paint for all classes of skins is prepared as follows: 60 lb. of unslaked lime, 25 lb. of sodium sulphide, and 20 gallons of water. A wooden tub should be used for slaking and mixing. A thin layer of the unslaked lime is then placed on the bottom of the tub, and on this a thin layer of sodium sulphide crystals, followed by another layer of lime. The two ingredients are thus placed in alternate layers until all has been placed in the tub. The necessary amount of water to effect thorough slaking is now added a little at a time (about 10 gallons of water will be sufficient). After slaking, the mixture should be left over night, the remaining 10 gallons of water are then added, and the mixture is thoroughly stirred. Before being applied to the skins, it is better to pass the mixture through a fine sieve to remove any small lumps of unslaked lime, stones, etc.

For the finer grades of leather, such as lambskins and goatskins for glazed and glove leathers, upon which fine grain is essential, the use of paint composed of lime and red arsenic is preferred. It is better to mix the arsenic sulphide and the lime before slaking, so that the heat produced by the slaking of the lime produces calcium sulphydrate.

M. C. Lamb has given the following method: "The arsenic sulphide is mixed with the unslaked lime in a suitable receptacle, in alternate

layers of lime and arsenic, and the amount of water necessary to effect the slaking is then poured a little at a time over the mixture. Suitable quantities to use are 120 lb. of lime, 30 lb. of red arsenic, and 60 gallons of water. After the slaking has been performed, the mixture should be thoroughly mixed with a wooden spade, and diluted to the required consistence by the addition of 45 to 50 gallons of water. The paint should be allowed to stand over night before using, and may with advantage be passed through a fine sieve before being applied to the skins. When properly prepared, the paint should be pale green in color. Any trace of red or pink color is evidence that the mixture is not satisfactory, and that the necessary chemical reaction during the slaking process has not been satisfactorily effected."

**Depilating glove leather.**—The modern glove-leather manufacturer has to deal with all kinds of skins, but chiefly with goatskins and sheepskins. Owing to the scarcity of raw skins, he is not able to choose as much as he formerly did. Cape sheepskins form the glove-leather dresser's main supply, and these are now in general demand by tanners and leather dressers for a great variety of purposes, including boot and shoe uppers and bag work. The following information relative to glove-leather dressing is taken from an article in "The Leather Trades Review":

For painting fifty dozen average skins, 6 bushels of lime and 45 lb. of red arsenic are required. In preparing this mixture, care must be taken to get a perfect reaction between the lime and arsenic. This is best obtained by first thoroughly mixing the two together and breaking the lime into small lumps. The mixture should then be carefully and thoroughly slaked with water and made into a paste-like mixture which can be painted on the skins in the usual manner.

The skins are spread out on the floor or on a table, and the mixture is applied with a mop to the flesh side. As each skin is painted, it is folded over, flesh to flesh, and placed in a pile and left until the next day. When the painting is done in the afternoon, the skins are ready for pulling the next morning. The wool is generally sorted into four grades. The next process is liming, and the duration of this process varies, according to the skins under treatment, from 7 days to 2 or 3 weeks. The old one-pit method still obtains in many tanneries and is carried out as follows: The pit is started with 5 bushels of lime, and the pelts remain in the same for 2 days when they are withdrawn, and the liquor is strengthened by the addition of 2 bushels of lime. In this liquor the skins are left for a week, then withdrawn and a final addition of 3 bushels of lime is made to the liquor. The goods remain 1 or 2 weeks longer, as they may require.

The amount of lime given above is sufficient for 50 to 60 dozen Cape sheepskins, but much latitude must be allowed, as so much depends upon local conditions, the season of the year and the condition of the goods.

During liming, the skins are drawn several times, and when the process is completed, they are drained and allowed to soak in clean water for a day or two. The addition of a pail or two of lime to the water is recommended. When the liming is completed, the skins are trimmed and fleshed, and left in water containing a little lime, after which they are

passed through water to which some lactic acid has been added to accomplish a slight de-liming.

**Patented depilatories.**—In addition to sodium sulphide used for the purpose of removing hair and wool from hides and skins and preparing them for tanning, patented depilatories are obtainable, largely made from the same chemical, which have many points to recommend them, being very satisfactory for both wool-pullers and tanners to use; and the leather which is made from skins treated with them is characterized by toughness, pliability, and fine grain. These depilatories are used in various ways according to the kind of skin being treated and the qualities desired in the finished leather.

*Depilatory paints.*—Following are several more prescriptions for making the paint:

Put 25 lb. of lime into a tub, and add just enough hot water to cover it. Stir the lime until it is entirely slaked, and add more water as it is needed. In another tub or barrel dissolve 25 lb. of sodium sulphide in 10 gallons of hot water. Mix the lime and the solution of sulphide together, and allow the mixture to become cold before applying it to the skins.

A suitable paint is prepared as follows: Mix 60 lb. of lime, 30 lb. of sodium sulphide and 20 gallons of water. Place a thin layer of the lime upon the bottom of a clean tub or vat, sprinkle on this a thin layer of the sulphide, and spread the remainder of the lime and sulphide in alternate layers. Ten or twelve gallons of hot water are next added, a little at a time, the mixture is thoroughly slaked, and is then left over night. The remainder of the water should be added, and then stirred up to a paint-like consistence. It is always advisable to pass a depilatory paint through a fine sieve to remove particles of unslaked lime, small stones, etc. Hydrated lime is better than lump lime, and if the former is used, the proportions should be 60 lb., 40 lb. of sodium sulphide, and 20 gallons of hot water.

A good depilatory is made by dissolving sodium sulphide in hot water until the solution stands at 18 or 20° Bé (Baumé)

test, and then adding 18 gallons of slaked lime. Apply this mixture to the skins when it is cold.

A mixture of lime and red arsenic can be recommended for loosening the wool on skins for glove or glazed leather, since it makes fine, smooth grain. The proportions are 100 lb. of lime and 25 lb. of arsenic, the two being thoroughly mixed together dry, and then slaked with 50 gallons of hot water, and passed through a fine sieve.

*Applying the depilatory paint.*—Spread the skins, one at a time, upon a table and apply the prepared paint upon the flesh side; then fold the skin with the wool on the outside, and place in piles until the next day, when the wool can be easily removed. Only enough of the mixture should be used to saturate the skin and cover it evenly, and none should be allowed to run off into the wool. Rubber gloves should be worn to protect the hands during this work.

When the weather is cold, 6 or 7 skins may be placed in a pile; but during warm weather not more than 3 or 4 should be so placed, and if they are to be left for 24 hours or longer, they should be singled out and each pelt should lie by itself. The wool becomes loosened in a few hours, but it is best if it is not removed until the next day. Very young lambskins, however, should be "pulled" as soon as the wool is loosened, and then put into cold water to which some sodium sulphide has been added. They may be kept in this water for some time without injury, although it is advisable to pass them promptly into the lime.

**Liming after removal of the wool.**—To start the liming of the skins, use 20 lb. of hydrated lime with 6 gallons of water for 100 average skins. Put the lime into water in a vat; put the skins in and leave them 1 day; then haul them out, and add 10 lb. of lime with 5 gallons of water, and put the skins in for another day, then haul them, add 7½ lb. of lime, and return for another 2 days.

**Liming for Mocha and castor gloves.**—In the depilation of skins for Mocha, castor, buff, and chamois leather, it is necessary to employ a long liming, which in some cases is pro-

longed to 30 or 40 days. For this treatment strong limes are also used, and a certain amount or arsenic sulphide is usually added. The outer grain is then removed on a beam with a round stick, the operation being known as frizzing.

**Method of using arazym on goatskins.**—*Soaking.* It is very important that the skins be thoroughly milled and soaked, and it is advisable to soak them for one day more than is considered sufficient for the lime or sulphide processes. See that the heads and necks are carefully worked out, that is, freed from grease and flesh.

*First day.*—Make up the following solution for each 100 lb. of skins, dry weight in hair:

| | *Light weight skins* | *Heavy weight skins* |
|---|---|---|
| Water, gallons | 125 | 125 |
| Caustic soda (76 per cent), pounds | 3½ | 4 |
| Temperature, degrees F. | 80 to 82 | 83 to 85 |
| Time to remain in caustic solution, hrs. | 36 | 48 |

Heavy hard-natured skins may stay in the liquor for 60 hours.

Run the skins in the paddle one hour when first put in, and then for 10 minutes each, in the evening before closing down and in the morning when starting up.

When the skins are to remain in the caustic solution over Saturday and Sunday, put them into liquor late on Friday, and reduce temperature 5° (according to the nature of the skins).

The pack that has to stay in the caustic solution on Sunday and Monday is put into the solution as late as possible on Saturday, with a drop in temperature of about 8° (according to nature of skins).

*Third day.*—Run off the caustic solution, and put the skins into a solution consisting of 10 lb. of bicarbonate of soda and 125 gallons of water for 100 lb. of skins, dry weight in hair. The temperature after the skins are in is 80 to 84° F.

Run for one hour, then add, according to the nature of the skins, for lights, 12 oz. of arazym, and for heavies, 16 oz. of arazym, per 100 lb. of skins, dry weight in hair. Run

for 20 minutes more, then leave in solution until the following morning.

When skins are to remain in the de-hairing bath over Sunday, drop the temperature 10°, and reduce the arazym 30 per cent, which means 8 oz. for light skins, and 12 oz. for heavy skins.

*Fourth day.*—Take the skins out and unhair. It is important that the skins from the unhairing machine be put into tepid water (about 65° F.) at once. They should not be left in dry condition either in a box or on a pile for any length of time. Wash in tepid water for 10 minutes, then flesh. If after fleshing the skins do not go into the bate at once, put them into tepid water. Weigh skins and then bate with "oropon A special" as follows (it is very important that the quantities of water and skins are in the right proportion, and for each 100 lb. of skins there should be 400 lb. of water).

*First liquor.*—The skins are washed in the old bating liquor used for the previous pack over night at a temperature of 85° F. for light skins, and 90° for heavy skins. The time of bating is 10 minutes (paddle 5 minutes). If no old oropon liquor is available for the first pack, substitute a solution of 4 oz. of oropon per 100 lb. of skins.

*Second liquor.*—In the second bating liquor the skins are bated over night. The quantity of oropon required is 16 oz. per 100 lb. for heavy skins, and 12 oz. for that quantity of light skins. The temperature should be 90° for heavy and 85° for light skins. Paddle 5 minutes.

The oropon necessary for the first pack is fermented in five times its weight of water for 24 to 48 hours at 110° F. (24 hours in summer, 48 hours in winter). From the second pack on, that is when for the preliminary bate an old overnight bating liquor is available, it is not necessary any more to ferment the oropon, but it is simply added to the fresh bating liquor before the skins go in.

After the skins are in the bating liquor, make certain it is on the alkaline side, that is, you should get a fair reaction

with phenolphthalein, and if not, add ½ per cent of soda ash on the weight of the skins.

When bating over Sunday, either put the skins into the bating liquor on Saturday afternoon, without the preliminary washing in the old bating liquor, reducing the temperature about 5° and the quantity of oropon about 25 per cent; or do the bating on Sunday in the usual manner, taking care,

Figure 54.—Fleshing.

however, that the skins, over Saturday and Sunday, are left in water made strongly alkaline by the addition of a solution of saturated lime water.

*Fifth day.*—Take skins out, slate, wash for 5 minutes in tepid water in paddle, and tan as usual.

For the swelling and de-hairing liquors it is advisable to take into one paddle a comparatively small quantity of skins with a large volume of water—about 125 gallons for 100 lb. of skins in the hair, dry—because in these liquors the skins are considerably swollen. After the skins are de-haired, washed, and fleshed (figure 54), they do not take more room

than in the ordinary bating process, and the quantity of water (50 gallons per 100 lb. of skins, bating weight) is sufficient. For the swelling and de-hairing liquors, take 3 reels for a quantity of skins for which in the regular bating process you would take one reel. For instance, if the regular bating packs consist of 900 lb. of skins, divide this quantity for the swelling and de-hairing liquor into 3 paddles each containing 300 lb.; however, for bating in the oropon special put them all into one paddle again.

The finished leather is improved by giving a somewhat heavier bottoming with vegetable tan in the dyeing, so as to fill it up. Care should also be taken to dry slowly at moderate temperature.

# CHAPTER IV

## DE-LIMING, DRENCHING, BATING, PUERING AND PICKLING

It is essential that the lime or other depilating agent should be completely removed after it has done its work, since its action on tanning is very injurious. Its presence has a tendency to weaken the fiber or produce a harsh-feeling grain. For sole and belting leather it is only necessary to de-lime the stock, and for soft leather this de-liming should not only be complete, but the stock should be brought to a flaccid and open condition. Ordinary de-liming may be accomplished by weak organic acids or certain chemicals, while bating, puering, and drenching, all of which tend to produce soft leather, must be brought about through fermentative, bacterial or enzyme action. Pickling consists in treating the de-limed, bated, puered or drenched stock with a combination of salt and acid, usually sulphuric. Drenching, which consists of a fermenting infusion of bran, sometimes follows bating or puering, but it is often resorted to independently of the other treatment.

The two terms "bating" and "puering" formerly meant two distinct processes, the former being applied where pigeon or hen manure was used, and the latter where dog manure was employed to remove the lime and open up the stock. Today, however, bating is most commonly used, and puering only in connection with the conversion of goatskins into leather.

**De-liming.**—Where de-liming only is desired, this may be accomplished by purely chemical means. Lime, being of an alkaline nature, adheres tenaciously to the hide fiber, and so cannot be readily removed by washing in plain water. An excess of strong acid must be avoided on account of its swelling effect upon the pelt, with subsequent damage during the tanning operation. What is especially required is that the de-liming agent should form an easily soluble com-

pound with the lime. An excess of the reagent must not have an injurious action on the pelt, and it must be obtainable at low cost.

*Test for de-liming.*—A simple test to ascertain whether skins are sufficiently bated and de-limed is to touch a cut edge of the skin with phenolphthalein solution. If there is lime still present, a violet coloration is produced, but when the skin is entirely de-limed, there is no such coloration.

*Sulphuric acid.*—By exercising great care this acid may be used as a de-liming agent for stock that is to be tanned in acid hemlock liquors. The stock should be run in a much diluted, slightly warm solution, until the lime is nearly neutralized; it is then thrown into clear water to finish the de-liming.

*Hydrochloric acid.*—This mineral acid is somewhat safer than sulphuric, but must be perfectly free from even a trace of iron, and the paddle should have no iron surface exposed.

*Sulphurous acid.*—The most satisfactory mineral acid is sulphurous. It may be generated as a gas by burning sulphur in a stove, and allowing the sulphur dioxide ($SO_2$) to be absorbed in water. An excess of this acid is not harmful to the stock, and leaves it in a somewhat plump condition.

*Sodium bisulphate.*—Ordinary nitric-cake may be used in place of sulphuric acid. This material is a by-product from the manufacture of sulphuric acid, in which sodium nitrate is treated with sulphuric acid to furnish the necessary amount of nitric oxide required during the process Care must, therefore, be taken to guard against the presence of any nitric acid in the product.

*Boracic acid.*—This may be used to advantage as a surface de-liming agent on sole leather, the amount required being about 2 per cent on the weight of the stock. Experience has shown that the treatment should be carried out in a paddle, otherwise patches will appear giving irregular color to the finished leather. Among the various chemical de-liming agents and bates which may be used in preparing hides and skins for tanning, boracic acid is one of the most efficient

for that purpose. The hides or skins are bated in the usual manner, and are then immersed in a drench of boracic acid, which removes the last trace of lime, and makes the grain soft and clean. When the acid is used alone for the purpose of de-liming it makes the grain soft and silky, hastens the tannage, and prevents the grain from becoming contracted in the tan liquor. Light skins for chrome and vegetable tanning are sometimes given a drenching with boracic acid after they have been bated, a paddle being used during the operation. When soft, silky, leather is required, it is advisable first to use a commercial bacterial bate, such as oropon, and then drench with boracic acid, and pickle with formic acid and salt. Excellent results as regards grain, texture, and color are assured when skins are treated in this manner.

*Carbonic acid.*—The use of carbonic acid has been suggested as a de-liming agent, in which case the carbon dioxide gas ($CO_2$) is allowed to bubble through the water in the paddle. The first action is to form the neutral carbonate, but as more carbon dioxide is introduced, the soluble bicarbonate is produced and the stock consequently de-limed.

*Lactic acid.*—In recent years this de-liming agent has come into general use. Lactic acid is formed when milk sours. On a commercial scale it is produced by adding the lactic ferment to a solution of glucose. It comes into the trade either in a 30 or 60 per cent solution. When employed for de-liming, 2 lb. should be used for each 100 gallons of water, at a temperature of about 90° F. Like other de-liming agents, the best results are obtained in the paddle. A slight excess of this acid produces considerable plumping, which is a decided advantage in treating hides for sole leather or other heavy stock.

For 800 to 1000 average limed sheepskins, 20 lb. of lactic acid and 20 lb. of salt are used. The water in the paddle should be warmed to 85° F.; if it is cooler than this, more salt is required to keep down the plumpness. Half of the acid and all of the salt should be added to the water before the skins are put in, and the remainder of the acid after they have been in 15 minutes. The time required for drenching should

be about 45 minutes in a paddle; in a still vat or tub, 2 or 3 hours, the skins being stirred two or three times during that time. Several packs of skins may be put through this drench, with a fresh addition of 15 lb. of lactic acid for each succeeding pack, adding 5 lb. at first, and 10 lb. after the skins have been in 15 minutes. When drenched, the skins should be rinsed in warm water and pickled.

Lactic acid may be used for goatskins in the following manner: After the skins have been bated, prepare a bath in a paddle with warm water, and for 100 lb. of skins add ½ lb. of lactic acid and an equal quantity of salt. The water should be at 90° F. before the skins are put in; they are paddled 20 minutes, then rinsed and pickled. This method is advantageous for goods that are intended to be colored, as the acid cleanses them thoroughly. The process can also be carried out in a drum, in which case only a few minutes is required to remove the last trace of lime from the skins.

*Formic acid.*—This compound is prepared on a large scale by heating sodium formate with sulphuric acid. The resulting acid comes to the tanner as a 60 per cent solution. It is very effective as a de-liming and plumping agent, and many tanners prefer it to lactic acid. It is used in the same proportions as given for lactic acid.

*Formic acid and lactic acid drench.*—A mixture of 4 parts formic acid and 1 part lactic acid is efficient in drenching skins, less than ½ pint of the mixture being sufficient for 100 washed skins. The goods are paddled 30 minutes or longer in the drench at a temperature of 90° F., rinsed, and pickled. This drench may also be used after a regular bate. Drenched with formic acid, skins tan into clear-grained and uniformly colored leather.

M. C. Lamb, of the Leathersellers' Technical College, London, describes a method of de-liming and pickling with formic acid, which he has used successfully, as follows:

The goods, after washing free from surplus lime in the paddle water at 85° F. for 30 minutes, are ready for de-liming. The de-liming is best done in the paddle-wheel; the goods are placed in a vessel, together with sufficient water at 90° F.; paddling is commenced, and then the following

solution, previously prepared, is added: 2 lb. of formic acid (40 per cent), and 5 lb. of common salt, for each 100 lb. of limed skins.

The goods are paddled until flaccid and fallen, which will generally require about 30 minutes, when they are removed and are ready for pickling. Pickling is best carried out in a drum, but it may also be done in a paddle. The proportions recommended are 10 lb. of formic acid, 20 lb. of salt, and 20 gallons of water for 100 lb. of skins.

*Butyric acid.*—This is another chemical product of recent introduction. It may be used in the pickling of calfskins for chrome or vegetable tanning, especially for the two-bath process, when it is used in the following manner: The skins are bated with any satisfactory bate or in a bran drench, and are then pickled in a drum with a solution of 10 lb. of salt, and 10 oz. of butyric acid in 15 gallons of water for 100 lb. of skins. The skins are turned in this liquor for an hour; they are then given the first chrome process, which in this case is made of 4 to 6 lb. of sodium bichromate, 1 lb. of butyric acid, and sufficient water, say 15 gallons. This method of pickling and tanning is said to produce leather having a particularly soft grain and agreeable feel.

*Ammonium chloride.*—This material can be used to good advantage for dressing leather. It is a strong bating agent, converting the lime into calcium chloride, which is very soluble and easily removed. The ammonia generated, according to the Otto P. Amend process, may be neutralized with hydrochloric acid, and the bath used continuously. The amount of ammonium chloride used at the start should be about 3 per cent of the weight of the stock, and 1 per cent is added to each subsequent pack. The temperature should be maintained at about 90° F. to get the best results. This method is especially adapted to calf and side leather where a depleting action is not desired.

The following process is said to be excellent for goatskins for chrome tanning: Dissolve 20 lb. of sal-ammoniac (ammonium chloride) and 70 lb. of salt in 700 gallons of water at 95° F., for 50 dozen skins. Paddle the skins in this liquor for two hours, then leave them in over night. Sal-ammoniac acts upon the goods like a bate or puer, having, however, the advantage that the workman can control this process while he

cannot always control the old-time puering. The next morning the skins are transferred to the pickle in a paddle-wheel consisting of 10 lb. of formic acid and 8 lb. of salt, at a temperature of 85° F. After an hour in this liquor the skins are in condition to be tanned. This removes all the lime, and strengthens the fibers so they will stand the corrosive action of the chemicals and acids used in chrome tannage.

*Ammonium butyrate.*—One of the newer chemical products for de-liming and bating is made by neutralizing butyric acid with ammonia. It produces the best results as a bate when used upon skins that are to be put into the tanning liquors in a soft or neutral condition. The skins become perfectly de-limed, white, and soft, and no injury results when an excess is used. It may be used alone or with any other bate. For bating calfskins it is used alone, the quantity recommended being 1 to 1½ lb. for 100 lb. of skins. The ammonium butyrate is dissolved and added to warm water in the bating paddle. The goods are put in and paddled for a half-hour; then allowed to rest for 2 hours, and then paddled another half-hour, when they are taken out and either pickled or tanned.

*Sodium dichromate.*—The value of this process lies in the employment of a chromium compound as a base, a solution of it forming the main ingredient of the bate. The liquor may be prepared as follows:

Prepare a saturated solution of 2 oz. of sodium dichromate in water, pour it into a vat containing 1,000 gallons of water, and stir thoroughly. This quantity is sufficient for 20 to 40 hides, which are thrown into the prepared bate, and left therein for 24 hours, being stirred occasionally. The temperature of the bath should be about 80° F. The hides may be run in the liquor a short time, and then left in it over night or longer. They are then fine-haired, washed in warm water, and are ready to be tanned. About 2 oz. of dichromate are used for 2000 pounds of hides or skins, green-salted weight. The use of sodium dichromate as a bate has been patented by Henry Schlegel, of Lapeer, Michigan.

*Sodium bisulphite.*—This chemical has marked de-liming action, but on account of its acid character it does not produce a true bating effect. For certain classes of leather, however, it may be employed to advantage.

*Ammonium phosphate.*—For sole leather the use of such materials as ammonium phosphate and ammonium oxalate are said to have some value as de-liming agents. In using these salts an insoluble condition of the lime is produced which, remaining in the leather, helps to give it body.

*Zinc sulphate.*—When limed hides are thrown into a solution of zinc sulphate, a double decomposition takes place, which results in the formation of calcium sulphate and zinc oxide, both being insoluble in water. The hides are therefore filled and added body is secured.

*Coal-tar bates.*—Several of the aromatic acids have been suggested as de-liming agents, some of which have been used with more or less success. Among these should be mentioned crude cresotonic acid, a mixture of phenol and cresols; oxy-naphthoic acid; napthalene mono and disulphonic acid; salicylic acid; as well as phenol and cresol sulphonic acids.

Several years ago the Martin Dennis Co., of Newark, N. J., put on the market a preparation known as "C. T. bate." This compound consisted of a mixture of sulphonic acids, and was used in a 1 per cent solution. All of these coal-tar bates are more effective as de-liming agents than as true bates or puers.

**Drenching.**—By drenching is usually understood a method in which some form of fermentation is employed, the simplest of which consists of fermenting bran infusion. Not only is drenching employed to remove the lime and open up the stock, but it is often applied after bating or puering to bring the skin to a clean and acid condition. During fermentation, the principal products formed are lactic acid and acetic acid, together with some formic acid, butyric acid, hydrogen sulphide, and amines. Drenching takes place most satisfactorily at a temperature of about 90° F., and is usually complete in from 12 to 18 hours. Unless liquefying bacteria have been intro-

duced during the bating, no injury to the stock can result. The following suggestions may be found useful:

*Method of de-liming (drenching) with bran.*—Take a half barrel of bran, and add enough water to make it mushy; cover it up, and let stand in a warm place for 48 hours to sour. Into a vat large enough to treat 400 skins run the requisite volume of water and empty the sour bran into the same. Mix thoroughly, and heat to 90° F. Throw the pack of skins into the prepared drench, and treat them for 3 hours; heavy skins a little longer. The skins will be made soft and clean by this treatment, and, if intended for black leather, will require no working on the beam; but if for colored leather, it is advisable to work them out on the beam so that the grain will be clear and clean. Washing in warm water after drenching puts the skins into the best condition for pickling and tanning.

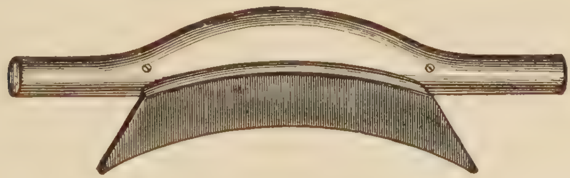

**Figure 55.—Bate beam-stone.**

*Other bran drench formulas.*—Take 50 lb. of bran; add water to make a mush, and let it stand until sour; then put the sour bran into a paddle together with 700 gallons of warm water, and process the skins until they are soft and clean. Rinse them in warm water; work them over the beam with a bate beam-stone (figure 55), and then pickle them. If acid is needed, 25 lb. of 28 per cent acetic acid should be added

A process of drenching which is especially recommended involves the use of bran and lactic acid in the following manner: Run water into a paddle-wheel and heat it to 120° F. Put two pails of dry bran into the warm water and let stand over night The next morning bring the temperature up to 95° F. Take one pint of lactic acid for each 100 lb. of skins, and put about half of it into the bran liquor; throw the skins in, and while the paddle is running, add the remainder of the

acid. Run the paddle for 2 to 4 hours, according to the thickness of the skins and the amount of lime in them, then take them out and rinse in warm water. This washing should not be neglected, especially if the leather is to be colored. The skins, after they have been rinsed, are ready to be pickled. For the second pack of skins, lower the drench liquor down about 12 inches, and run in an equal quantity of water. Heat the liquor to 95° F. Do not use any more bran, but take a pint of lactic acid for every 100 lb. of skins to be treated, and proceed exactly as described for the first lot. Continue in this way for 6 days; then run off the liquor and make up a fresh drench with water, bran, and acid, and proceed in the manner described. This method of drenching makes the skins soft and clean, and in good condition for pickling and tanning, no matter what the tannage may be.

The following also is a reliable bran drench: Take a half barrel of bran, add enough water to make it mushy, and let stand 48 hours to sour. When sour, empty it into a vat half filled with water. Add 6 pints of acetic acid and 3 pecks (45 lb.) of common salt, and heat to 95° F. This quantity of bating material is sufficient for 300 to 400 skins. Throw the goods into the liquor, and paddle for 4 or 5 hours; then wash them in warm water if for black leather, or work them over the beam and then wash them, if for colored leather. This process produces soft and clean skins which can be pickled and tanned by any tanning process.

*Mild fermented drench.*—A mild fermentation of an acid has proved to be a most satisfactory bate and de-liming process for hides which are to be tanned into soft, supple leather by a chrome or a vegetable tannage. Excellent results as regards full flanks, good break, and fine, even grain are obtained by allowing grape sugar or common glucose to become sour, and using definite portions of the same in combination with lactic acid for each pack of hides or grains.

The process is a simple one, and is easily carried out: Dissolve 100 lb. of grape sugar or glucose in 35 gallons of hot water in a barrel. Add several quarts of sour milk, and allow

to stand for two or three days at a temperature between 95 and 105° F., when fermentation should be completed. Prepare a paddle-wheel with water at a temperature of 95°, and put into it 2½ quarts of the sour sugar solution. For every 100 lb. of stock to be bated take 1 pint of lactic acid, and put about half of it into the prepared bate in the paddle-wheel before putting in the hides, and when the latter are in, add the remainder of the acid. Three or four hours are usually sufficient to run the goods in the paddle-wheel. On being taken out, they should be thoroughly washed with water. The importance of this simple washing is too often overlooked, and its necessity cannot be over-emphasized if a good clear grain, which will color evenly, is desired. For the second pack of hides, the bate liquor is lowered about 12 inches in the paddle-wheel, and the loss made up with fresh water. The temperature is brought up to 95° F., and 2½ quarts of the sour sugar solution and 1 pint of lactic acid is added for every 100 lb. of stock, as directed for the first pack. Continue in this way, running off a little of the liquor for each pack, for 6 days; then run off all the liquor, retaining, however, about a barrelful with which to mellow the new liquor, which is prepared with fresh water.

It should be pointed out that the amount of sugar solution used, namely, 2½ quarts per pack, is based upon the volume of liquor in the paddle-wheel. The average capacity of a paddle-wheel is between 2000 and 2500 lb. of stock. The action of the sour sugar is, however, so mild, that a wide range in the weight of the stock bated with the given quantity of the sugar solution is permitted without danger.

**Puering and bating.**—Under this head are included such materials as give the results desired through bacterial or enzyme action.

The process commonly called bating or puering frees the skins from lime and alkaline sulphides acquired during the process of liming, and makes them soft and clean and in the proper condition to be pickled and tanned. Hen and pigeon droppings and dog dung have been used for many years and

although these materials are unpleasant, they produce results difficult to obtain by the use of others, and many tanners continue to use them. Goatskins are sometimes puered with a mixture of chicken droppings and dog dung, but the latter is also employed alone.

To prepare the material, soak it in hot water for two or three days before using. Mash it well, stir it occasionally, and strain it through a wire strainer to get rid of pebbles, feathers, etc.; this, however, is not always necessary. The skins should first be washed in warm water to remove surface lime, then be placed in a used bate liquor which has been warmed to 80° F., and left in the same for 12 hours. From such liquor they are placed in a fresh bate warmed to 85°, and paddled in the same for several hours, or until they are soft and silky. They are next fleshed, scudded, rinsed or drenched, and pickled or tanned.

*Bating with molasses.*—Sour molasses makes an effective bate for hides for heavy leather. The molasses is soured by putting 7 gallons into a barrel of water, adding 1 gallon of milk to assist the souring, keeping the solution at 90° F., and stirring occasionally until sour. More than one barrel is required, so that more molasses can be souring while the first is being used.

To use the sour molasses, fill a paddle-wheel with enough water to cover 50 sides, and add 8 pails of the sour molasses The sides remain in the bate at least 30 minutes, and a longer bating will do no harm, although there is always danger of bating too low. Judgment must be used as to how long to continue the process. When the bate becomes weakened by the lime which works out of the hides, more sour molasses should be added, say 6 pails to 200 sides. If the paddle holds 50 sides, put in 1½ pails of molasses after taking out each pack of hides, and keep the temperature of the bate at about 80° F. The bate should not be made fresh for each lot of hides, but molasses should be added to it. When the bating is over, withdraw the hides and rinse them in cold water in another paddle-wheel for a few minutes, and then put them onto sticks

for the tanning liquors. The bated hides will contain considerable lime, but a few hours in the liquor will take it all out.

*Bating with glucose, sulphur, and yeast.*—In working with this process, the skins are limed, unhaired, and washed. A bath at 95° F. is next prepared, consisting of 5 per cent glucose syrup and 1 per cent sulphur, computed on the weight of the skins, and about 1 lb. of yeast for every 1000 lb. treated. The bath prepared in this manner is allowed to stand 24 hours to become thoroughly fermented. At the end of this period the temperature of the liquor is raised to 100°, and the hides or skins are put into it.

In order to have a continuous bath, half the original quantity of sulphur, glucose, and yeast is added at the same time. In working this process, it is not necessary to keep the skins constantly in motion, but only stir them occasionally. Heavy hides will be free from lime and in soft and open condition at the end of 8 hours; lighter skins in a proportionately shorter period.

On removing the pack, the temperature of the bath may be raised, and after adding half of the original quantity of sulphur, glucose, and yeast, another pack may be treated, thus making it possible to work two packs each day in the same vat. It will be understood that a continuous bath would in time become too concentrated from solutions of calcium compounds, and thus prevent or retard fermentation. This difficulty is obviated by drawing off half of the solution every time after treatment of the second pack.

The hides or skins show no trace of lime after treatment, and they are soft and open, and have a smooth, silky grain. As there is nothing in this bate to cause putrefaction, there is no loss of hide substance, and the skins, without further drenching, can go at once into the tan liquors. Where pickling is part of the process, the skins can be pickled at once and then tanned. This is the Oaks patented process of bating.

By adding 2 per cent of ammonium chloride in the first bath, the efficiency of the bath can be improved.

*Dog dung.*—Despite the unpleasantness of its use, dog dung

is an efficient bate for leather that requires a soft, fine, and silky grain. The material may be used alone or combined with the droppings of hens and pigeons. If dog manure is kept for some time, it becomes heated of itself, burns up, and becomes useless; consequently, it is placed in barrels, covered over with enough water to soften it, and allowed to ferment for two weeks, or until it has resolved itself into a pasty condition. In this way it can be kept for months in covered barrels without losing any of its bating action. When it is to be used, it is stirred into boiling water (by this means a great many of the bacteria are killed, but not the spores) until, after decanting off several times, all of the soluble matter has been removed, and only the waste portion remains behind; but all sand must be allowed to settle again from the liquor, because if any is allowed to remain it is likely to injure the grain. This settling is best done in a large vat.

For 100 pieces of calfskins or 50 sides it is customary to reckon about 10 to 12 quarts of dog dung, while for 30 dozen sheepskins about 50 lb. of the material are used; and for 1000 lambskins or goatskins, 100 lb. or more. The proper amount of the bate is placed in the paddle-wheel in water sufficient for the pack of skins to be treated. The temperature of the liquor at the beginning should be about 90° F. The skins should remain in the bate for 2 to 3 hours, or at the longest, until the flesh remaining on them can be readily removed. It is injurious to the skins to bate them too long.

After the process is completed it is well to rinse off the skins, and then place them at once on the beam or the fleshing machine. By placing them in fresh water, the flesh becomes tender and is not removed as readily as when it is in the mellow condition in which it comes from the bate; consequently, as little water as possible is used, so that the mellowness of the skins is not lost.

In this process of bating it is easily possible for undesirable fermentation to take place and injure the skins. The duration of the bating in a normal case should occupy a definite time, regulated by the temperature, strength of the liquor, and tex-

ture of the skins, as well as by the degree of fermentation which the bate has developed. This method of bating is not patented.

*Hen manure.*—For calfskins and side leather it is customary to employ hen or pigeon manure in place of dog manure. The usual quantity used is a half bushel to 50 sides or 100 skins. The manure is placed in a barrel with warm water and allowed to ferment for several days, when it is added to the paddle liquor. Manure bates may be used for some time without changing, but care must be exercised to prevent too violent an action, which may damage the stock, causing what is known as "bate runs"

*Dermiforma.*—This is a prepared bacterial bate which has been introduced as a substitute for the old-time bates. The methods of using it described below, have proved satisfactory and the results desired have been obtained.

It should be remembered that bacterial action is governed by different temperatures, and if it is desired to reduce or deplete the hides or skins, the temperature of the bating liquor should be kept close to 95° F. during the process. Experience has shown that a different grain is obtained at different temperatures; consequently, if the liquor is kept near this temperature, the skins will be reduced more quickly and the grain will be finer. This applies to all classes of stock.

The quantity of dermiforma to be used for every 100 lb. of skins varies. In the bating of goatskins, 4 lb. are used, and the same quantity in bating calfskins. Sheepskins, however, may be bated with 2 lb., and the same quantity bates hides and kips, while sealskins require 3 pounds.

It usually requires about four hours to get calf, seal, and sheepskin in condition to be pickled or tanned. It requires good judgment to determine the exact time for the bating process; consequently, no general rule can be laid down, as some tanners do not bate hides longer than two hours at 95°. If it is desired to plump the stock, 1½ lb. of the bate will be sufficient for 100 lb., the time required being generally from 2 to 4 hours, and in some cases where hides are being plumped

for sole leather, they may remain in the liquor over night. The temperature should be normal or not over 80° F.

In using dermiforma in tanning liquors—either sweet or natural sour liquors—1½ lb. to every 100 lb. of green hides will plump them, and the leather will gain in weight. Where extract liquors are used entirely, the result is better, and the tannage more rapid with the above proportions. In all cases, the hides must be thoroughly washed from the limes, or the proportions given will not suffice. More bate is required when an excess of free lime is carried into the bating process.

Bating is done most advantageously in a vat with paddles, and not in a stationary tub, as the action of the paddles causes the liquor to be stirred, thus de-liming more quickly. A warm bate depletes or reduces the goods; a cold bate plumps them. When de-liming is completed, and the skins are soft and silky to the touch, they should be removed from the bath, rinsed in warm water, and then either pickled or tanned. Skins are bated most satisfactorily in warm liquor, while for hides for plump and heavy leather a cold bate is best.

*Dr. Rohm's bate "oropon C" for regular packs.*—Treatment of the skins before the bate is the same as usual. It is advisable to wash them thoroughly before the bate to free them as much as possible from lime. In the case of sulphide, neutralize as usual. For this bate the quantity of water and temperature are as usual, and the time of bating is 2 to 4 hours for calfskins, and 4 to 6 hours for hides. The quantity of oropon is always calculated on the weight of the wet skins and according to their nature thus:

8 to 10 oz. per 100 lb. for calf and split grains, and 10 to 12 oz. per 100 lb. for insplit hides (used for furniture, etc.)

The liquor can be re-used, and in this case add, for the second and following packs, about half or even less of the oropon used for making fresh liquor. It is advisable to warm the old liquor over-night the first two days to accelerate fermentation. After the liquor has been used two days it will be noticed that fermentation grows stronger. To keep it in

control, run off each day about 6 to 12 inches of the liquor (more in summer than in winter). Before running off, stir the liquor well to get rid of as much dirt as possible. As a rule, make up the bate fresh once every two weeks, but in doing so, leave about a fourth of the old liquor in the paddle.

*Bating process.*—Always heat the water first, then put the oropon in undissolved. After stirring thoroughly put in the skins. The further treatment is the same as usual. Watch the process closely to see how the skins fall, and do not take them out until they are as low as desired. In case they fall too quickly, reduce the quantity of oropon proportionately the next time. If they do not fall enough, add to the bate 0.1 to 0.2 per cent of oropon (dissolved in a bucket of water and added while the skins are paddled), at the same time raise the temperature of the liquor in case it has cooled down too quickly. If, after one hour, the skins are still too high, repeat this operation until a satisfactory result is obtained. The next time a correspondingly higher concentration is used. If over night bating is preferred, use about 20 per cent less oropon than indicated above, and a temperature of from 80 to 90° F. before skins are put in.

*Dr. Rohm's bate "oropon A B" for limed goatskins.*—Use 30 gallons of water for each 100 lb. of skins, and the usual quantity for regular packs.

*Bating, first liquor.*—The skins are first washed in an old bating liquor. If no old oropon liquor is available, substitute a light solution of 4 to 6 oz. of oropon for each 100 lb. of skins or better, wash the skins in the used dog-manure liquor.

*Temperature.*—For soft skins, 90 to 95° F. (before the skins are in); for hard skins, 95 to 105° F. (before the skins are in).

*Second liquor.*—In this liquor the skins are bated over night (put in about four o'clock, paddled 10 to 15 minutes, and left until the next morning). In the morning they are paddled again for 15 minutes, and if low enough, are taken out. In preparing the bating liquor, always heat the water first, then

put in the oropon without previously dissolving it, and, finally put in the skins.

*Quantity of oropon for* 100 *lb. of skins.*—For South Americans, Brazils, etc., 8 to 10 oz.; for Russians, 8 to 10 oz.; for Chinese, 12 to 16 oz.; for Mochas and Patnas, 14 to 16 oz.; and for Northwesterns, 16 to 18 oz.

*Temperature.*—95 to 105° F. (before skins are in), according to the nature of the skins.

In case the skins are not reduced enough, add more oropon, starting with about 20 per cent of the original quantity. If, after about an hour, the skins are still too high, repeat the operation until the skins are as low as desired. The next time, of course, correspondingly more oropon is used. In bating over night, fermentation will raise the skins to the surface of the water, which action is desirable. It is probable that the first two or three packs will not come up, as the fermentation is too weak at the start. It will strengthen gradually, however, and the fourth and following packs will rise over night.

*Martin Dennis' "puerine."*—Take a clean 50-gallon barrel, remove the head, put in 25 gallons of water and heat to 130° F., then, while stirring vigorously, put in 100 lb. of puerine. Cover the barrel with an old burlap bag to assist in retaining the heat. After 24 and 48 hours, add 10 gallons of water at 140° F., stirring well each time. At the end of 72 hours the puerine is ready for use. The barrel will be full, and each gallon taken therefrom will contain 2 lb. of puerine. When using the prepared puerine always stir thoroughly before taking any from the barrel.

*First pack.*—Have the desired quantity of water in the paddle, heat to 95°, put in stock, and then add, for every 1000 lb. of stock, 12 lb. of puerine (6 gallons of the prepared puerine).

*Second pack.*—Use 8 lb. of puerine (4 gallons of the prepared) for every 1000 lb. of stock.

*Third pack.*—Use 6 lb. of puerine (3 gallons of the prepared) for every 1000 lb. of stock.

*Fourth and all following packs.*—Use 4 lb. of puerine (2 gallons of the prepared) for every 1000 lb. of stock.

Once a week allow the puer paddle to settle for four hours, then draw off from the top about a fifth of the bating liquor. This is easily done by having a plug on the the side of the pit at the proper distance from the top. Clean out the pit thoroughly every three months by drawing another plug from the bottom.

It is impossible to explain here how long the stock should be bated, but it should be left in the bate until in the judgment of the operator, it is "low" enough.

The puerine bating liquor improves with age, and it must not be expected that the first few packs will be as well bated as those which follow. In this respect it is the same as a manure bate. When the bating assumes a bluish, slate color, it is in prime condition. If, at any time, this puerine bating liquor suddenly becomes yellow, it is an indication that too little puerine is being used.

*Puerine D.*—The Martin Dennis Co. of Newark, N. J., has also on the market a bate which is used the same as oropon. This bate, as well as oropon, is made from dry pancreas combined with ammonium chloride and some inert material. Its action depends upon the presence of tryptase and to some extent on lipase, the former acting as a solvent on the albuminous material, while the latter has the tendency to break up the fats.

**Pickling.**—After the stock has been bated or puered it is necessary to drench or pickle it before tanning. Drenching is usual where the stock is to be vegetable tanned and pickling is employed where chrome tannage may follow. The subject of drenching has been covered above, and the same methods as outlined may be applied after the bate. The following suggestions will be found useful when pickling is desired:

*Sulphuric acid and salt.*—To 40 gallons of water, add 40 lb. of salt and 5 lb. of sulphuric acid; this forms a stock pickle, 12 gallons being used for 100 lb. of skins. The pickling is

accomplished most rapidly in a drum, the skins being run in the liquor at least 1½ hours, then allowed to press and drain over horses for several hours or until the next day.

Another formula calls for 2 lb. of sulphuric acid, 15 lb. of salt, and 15 gallons of water for 100 lb. of skins. The drum containing the skins is started, and after it has turned a few times, the solution of acid and salt is poured in and the drumming is continued from 15 to 30 minutes. Either of these processes produces good results, and there is no guesswork about the quantity of acid and salt to use, and therefore no uncertainty.

*Formic acid and salt.*—The formula for this pickle is 10 lb. of the acid, 20 lb. of salt, and 15 gallons of water for 100 lb. of skins. The process is carried out in the same manner as with the sulphuric acid. An excellent way to pickle the skins, no matter which acid is used, is to put them into the drum together with three quarters of the water needed. The salt is dissolved in the remainder of the water, and the acid is added to it. The drum is started, and the acid and salt solution is poured in through the trunnion, and the drum allowed to run 30 minutes.

*Hydrochloric acid and calcium chloride.*—In the manufacture of white chrome leather, a decided advantage in color may be obtained by using a pickle of calcium chloride and hydrochloric acid. To prepare this pickle, make up a solution of calcium chloride by dissolving 40 lb. of the salt in 40 gallons of water, and add 8 lb. of hydrochloric acid. To pickle, use 12 gallons for each 100 lb. of stock.

**Pressing grease from pickled sheepskins.**—The following method of removing grease from pickled sheepskins has been found satisfactory in many cases: Get a sufficient number of sheet-iron plates as large as the press (hydraulic) will take, about 1/16 inch thick. Place one dozen skins on each plate, and spread out flat with the bellies and shanks folded in so as to have each plate of the skins about the same size. Place the butt of one skin as evenly as possible over the other until the press is full. It will be seen that the pressure comes

directly on the parts of the skins that need it most. After the pressure has been applied and the skins have been pressed, throw them into a drum, together with warm salt water, and drum them until they have come apart and are well opened out. They are then in condition to be tanned.

It is advisable to place sawdust or bran between the layers of skins to keep them from slipping, and apply the pressure very slowly as the stock is easily damaged at this stage.

**Gargoyle de-greasing fluid.**—This preparation is used for de-greasing pickled sheep, goat, dog, and other skins carrying a large percentage of animal fats. The following process produces satisfactory results when the pickled skins contain a minimum amount of moisture but no dry spots. If there are any dry spots they should be wet down when taken from the casks in the drained pickled condition, then proceed as follows:

Weigh the skins, separate each bundle by picking them apart one by one, place them in a clean drum without any water or other materials, and mill them in that condition for 5 to 10 minutes, or until they are opened up free from wrinkles and quite plump. Then for each 100 lb. of pickled stock, take from 1¾ to 2½ gallons of de-greasing fluid, and heat to 100° F. in a steam-jacketed kettle or over an electric stove, or by similar means where it is possible to avoid introducing any moisture. Add the de-greasing fluid to the mill with the skins, and mill together for about 30 minutes.

If the skins are entered in the evening and they are very heavy or greasy in the necks and backs, which will be the case if many bucks are among them, it is advantageous to let them lie in the drum over night, and then mill again in the morning for about 15 minutes. Then add through the gudgeon of the drum sufficient (1 lb. to the gallon) salt solution at 100° F. to allow the skins to become wet; although without sufficient solution to cause them to float. The process is most efficient where there is no excess of water at this stage. The pickled stock, put in a drum 4 feet high and 8 feet diameter, should not exceed 400 lb. In this condition the skins should mill

about 15 minutes, when there should be added through the gudgeon of the drum enough salt solution to float the skins freely. Next, pull the plugs or put on a slat door to flush out the salt solution and grease. Put on the tight door again, and slowly feed enough salt solution at a temperature of 100° F. to float the skins; then again put on the slat door and flush out. The skins are now ready for tanning.

During this operation, in addition to removing the animal grease, a good deal of the acid is extracted, thereby leaving the skins in the best possible condition for tanning. In this way the necessity of drawing pickle is eliminated, also the wringing and pressing of skins.

**De-greasing fluid.**—This attacks the "sheep grease" contained in the skins, dissolving and diluting it, so bringing it into solution; and when washed with warm brine (salt water) the grease is all removed. Precaution must be taken that the temperature does not exceed 100° F., and that the pickled skins are kept in contact with the saturated brine while washing, or they will bloat and be destroyed.

By this process, which naturally makes a flat leather, there is no danger of breaking the grain or distending the fiber. The process is beneficial to the stock, whereas wringing or pressing is detrimental; and perfect results are secured in the single operation described.

*Recovered grease.*—The solution of fats and brine, as it flows from the drum while washing, should be collected in wooden tubs or a large vat, then heated to boiling point and allowed to stand for 1 to 3 hours. The oil and fat will come to the surface, and the brine should then be drawn from the tank through a spigot or wooden faucet at the bottom of the vat until it has all been drawn from under the oil. Then more water should be run in with the oil; boiled again to agitate it perfectly, allowed to settle the second time, and the water again drawn off. This operation should be repeated until all of the acid and salt have been washed from the oil, both of which are detrimental if the fats are to be used in the production of leather. Tests for acid should be made with

methyl-orange and tests for salt with silver nitrate. Naturally some Glauber's salt is produced, which is also eliminated by this process. Two washings should be sufficient.

These recovered fats are valuable to the tanner, principally for making fat-liquors or emulsions. For sheepskins, it is recommended that one part of this recovered oil be added to two parts of "moellon degras"; then add an equal quantity of water, and boil it until thoroughly incorporated. The recov-

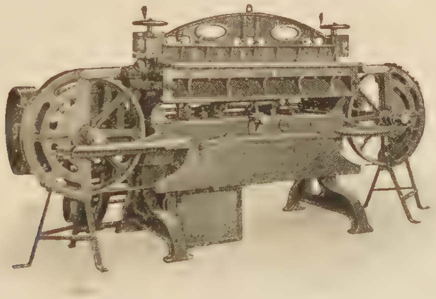

Figure 56.—Belt-knife splitting machine.

ered fat may also be emulsified by the addition of soaps or alkalies, although excellent results have been produced by using it as suggested above.

**Splitting out of lime.**—To make good chrome leather, hides should come from the unhairing machine firm and hard. If they are soft and flabby they will make poor leather, as there is nothing in chrome tanning that fills the hides or makes up for lost substance. After the hair has been removed, the sides should be washed in lukewarm water for 15 minutes and then worked over the beam for short hair. This work is important, as all fine hair must be removed; and even if there are no fine hairs, working out the grain opens up the cells of the hides and makes the grain fine and clear. After this work has been done, the sides should be put into cold water over night to harden for splitting. The next morning they are ready to be split. This is done on the belt-knife splitting machine, shown in figure 56. In splitting the sides, a 6-oz. grain from the machine will finish up $4\frac{1}{2}$ oz. of leather, as it loses $1\frac{1}{2}$ oz. going

through the various processes. All loose ends and pieces of flesh should be trimmed from the sides before splitting is begun, so that there will be nothing to interfere with the hide feeding freely into the machine. After the sides are split, they should be run in a wash-wheel with cold water for a few minutes to open them up and to remove the glaze caused by the belt-knife. The grains and splits are next bated.

**Splitting out of aluminum sulphate and salt pickle.**—Where hides are split out of pickle, a good procedure is to bate and pickle them with aluminum sulphate and salt in this

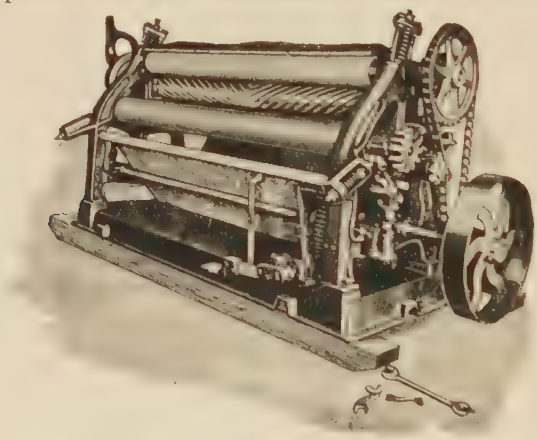

**Figure 57.—Rubber roll putting-out machine.**

manner: For every 100 lb. of sides, unsplit, and bated and washed, dissolve 4 lb. of sulphate and 10 lb. of common salt in 6 gallons of boiling water; then add 6 gallons of cold water and use the liquor after it has cooled to 70° F. Drum the sides in this liquor for an hour; then horse them up smoothly, and let them press and drain until the next day.

Hides pickled in this manner should not be pickled previously with acid and salt. If the splitting machine has a corrugated roll, the sides can be split right off the horse. If the machine has a smooth roll, the sides should be hung up to "sammie" (to become semi-dry), or pressed, or put out on a putting-out machine (figure 57), to prepare them for splitting. The grains should be the same thickness that the finished

leather is to be, as they do not fall away like grains split from limed hides. Hides pickled with aluminum sulphate and salt split as easily as bark-tanned leather and the splits are as good as those taken from the limed hides. After the sides are split, the grains can be shaved while in the pickled condition, this saving putting them out for shaving after they are tanned. Both the grains and splits are then ready to be tanned.

**Splitting after tanning.**—Tanning the sides in a chrome process and then splitting them is sometimes practiced. The sides are tanned in a one-bath chrome process in a paddle-wheel or by suspension, and when they are well struck through with the tan they are pressed and split. The pressing removes the surplus water and makes the leather drier and firmer. After pressing, the sides should be run in a dry mill until they are opened up and ready to be split, when they should be jacked the same as bark leather, and split to the thickness the finished leather is to be. After they are split, the grains are shaved and re-tanned.

**Splitting out of acid pickle.**—When hides are to be split in acid-pickled condition, they are allowed to drain 24 hours after being pickled, pressed to remove surplus liquor, and milled to remove the press-marks; they are then split to the required thickness. The grains can be shaved either after splitting or after they are tanned.

## CHAPTER V

### RAW HIDES: OIL AND ALUM TANNAGE

**Raw hide.**—For certain purposes, such as drum-heads, saddle-tops, bayonet scabbards, belt-pins and the like, a very strong and stiff form of leather is required. To make such a product, the hides or skins are soaked, de-haired, and bated in the usual manner, and after thorough washing are carefully tacked on boards, the tacking being strong and close. The skins are then allowed to dry slowly, and as they dry contraction takes place, causing a more or less transparent condition. When stripped, they are ready for market. When used, such skins are dampened with warm water and stretched into whatever form desired. Parchment is usually made from selected sheepskins treated in this manner.

For the manufacture of raw-hide pins, now used extensively for joining machinery belting, the hides are cut into strips, and while wet are twisted into shape and allowed to dry out under tension. Raw hide is also pressed into various shapes, such as hammer heads, washers, and the like.

**Lace leather.**—Raw-hide lace leather must be strong and soft, so it is necessary to separate the fibers and lubricate them so that they will remain pliable. This is accomplished by the following method: The hides are limed thoroughly and bated with ammonium chloride. They are then given a light tawing by milling with 5 per cent of aluminum sulphate and 5 per cent of salt dissolved in just sufficient water to float the stock. When struck through, they are piled down for 48 hours, and then split to weight. The sides are then hung up to dry, and when well crusted they are dipped in lukewarm water and packed down to sammie. The sides, which should now contain about 30 per cent moisture, are placed in the mill in a mixture of 5 per cent of cod liver oil, with 2 per cent of tallow at 120° F. added: The drum is run for two hours, and another portion consisting of 3 per cent of cod oil and 1 per

cent of tallow is added; and after another hour a similar quantity is added. When the sides have absorbed most of this oil they are set out on the machine, and then well set by hand, using a dubbing of 2 parts cod oil to 1 part of tallow. The sides are then hung over sticks to dry. When the stock is dry, it is dipped in lukewarm water and piled down, care being taken that it does not become too hot. A certain amount of heat, however, should be developed to cause oxidation of the cod oil. The oxidized stock is now re-set by hand, again hung up, and finally rolled.

In place of the cod oil and tallow, many tanners are now using a mixture of 50 per cent oleostearine substitute, 40 per cent of vacuum currier's wax, and 10 per cent of rosin, at a temperature of 140° F., using a total of 15 per cent of the mixture, and adding it in three portions as indicated above. Lace leather made by this process does not oxidize as quickly as that made from cod oil, and besides being less dangerous is less expensive. The same mixture is used for dubbing as for oiling, and the same procedure is carried out except in the case of packing down to oxidize.

*Shark-liver oil tannage.*—Where cod-liver oil is used for stuffing or for other purposes the author has found that the oil from shark livers can be used with equally good results; in fact, a stronger leather is produced with this oil than with cod or fish oils.

*Latigo leather.*—A very strong leather, and one used extensively where strength and body are desired, is what is known as "latigo leather." The process employed in making this is essentially the same as for raw hide. The point of difference lies in the fact that the sides, after splitting to weight, are run in a paddle with a solution of gambier of 15° bk. strength until the color is struck through. They are then dried out, sammied, and stuffed as described under raw hide. Some tanners improve the color of the stock by milling with a solution of auramine or picric acid.

Another method for making latigo leather is as follows: The hides are suspended in gambier liquor for a few days,

and then put into a solution of alum and salt. This process produces a thick grain which presents an excellent surface to the buffs. Stuffing is done with hard grease, degras, and cod oil. The leather is then shaved, buffed, and finally set out, first by machine, and then by hand. Tallow and oil are often used in stuffing lace leather, and when the grain is buffed off, there is, of course, no liability of its cracking and breaking when in use.

Some tanners also run the stock in a paddle-wheel containing a 15° bk. gambier solution and then finish with salt and alum; while others run the sides in a mixture of alum, gambier and salt. In all cases they are finished by stuffing as described above.

*Alum-tanned lace leather. No.* 1.—Put 30 lb. of alum and 50 lb. of salt into a clean barrel; add water, and boil with steam until the alum and salt are dissolved. Dissolve 6 lb. of sodium carbonate with hot water, and pour the liquor slowly into the alum and salt solution, which has been added to water in a paddle, plunging the liquor briskly Effervescence takes place when the soda solution is mixed with the alum liquor, and when it ceases, the liquor, to be in the right condition for use, should have a sweetish taste. If it tastes sour, add dissolved carbonate of soda and salt in the proportions stated until it tastes sweetish or neutral.

The liquor should be cold when the hides are placed in it. The tan liquor having been prepared, place about 400 lb. of washed sides into it. Run the sides 15 minutes after they have been placed in the liquor, again at the expiration of half an hour, and again at the end of the next half-hour, then at intervals of two hours until the close of the day. Frequent motion lays the foundation of an even tan and a uniform grain, two important considerations.

On the second day the pack is in the liquor, run it 4 times at regular intervals; on the third day run it 3 times; and on the fourth day, twice; and near closing time, haul the pack up to drain over night, and finish it the next day.

Tanning may be done also by drumming the sides with the

liquor for one day, stopping the drum at intervals, and then starting it again. The pack being tanned and drained, hang the sides up for part drying. The spots that dry hard should be wetted with water, and the whole of each side made uniformly moist and soft before grease is applied. Dampen the sides uniformly; fold and pack them in a box and let them remain 24 hours, when they are ready to be stuffed. The dubbing used to stuff the leather is made of pure tallow and neat's foot oil in the following proportions, according to the season of the year: In summer time, 10 lb. of tallow and 1 lb. of neat's foot oil, and in winter, 10 lb. and 3 lb. respectively. The leather may be stuffed with tallow only, but the addition of some neat's foot oil gives it a softer and mellower feel. Half a pound of rosin to 10 lb. of dubbing helps protect the dubbing from oxidation. The dubbing is applied in a fluid state at a temperature little higher than the melting point of the tallow, in the following manner:

Place on a table the number of sides the stuffing-wheel will carry, and spread them out upon one another. With a swab or suitable brush give each hide a light coat of the fluid dubbing on both flesh and grain. Place the batch in the cold stuffing-wheel, and set it in motion. The wheeling should be done in such a manner that the sides come into contact with the pins of the wheel, in order that the grease may be worked into the leather.

When the sides have absorbed the grease, take them out of the wheel and hang them up until they are partly dry. Then with a stone having well-rounded corners go over the sides on the flesh side and straighten them out, when they are ready for shaving. Shave them lightly and evenly. Then coat both flesh and grain with melted dubbing, and run the sides in the wheel again. Hang the leather up, and when it is nearly dry, snuff it over with the currying knife on the flesh side; set the flesh out; stone, slick, and glass the grain; oil lightly on the grain, and hang up to dry. Then take the leather down and glass it on the flesh and brush it on the grain, when it is ready for use.

*Alum tannage No. 2.*—A tanning liquor for lace leather may also be made of 15 lb. of alum, 30 lb. of salt, and sufficient water to cover 50 sides, which are kept in this liquor 24 hours. The liquor is then run off, and the sides are given 25 lb. of alum and 50 lb. of salt, and handled twice each day. They should remain in the liquor two days, and then be hung up to dry. When dry, they are dampened down for 2 to 3 days, and then worked out on the staker. To grease the sides, 50 lb. of white tallow and two quarts of pine tar are mixed, and applied hot to both sides of the leather. The sides are then put into the drum, heated with steam to 85° F., and drummed one hour. They are next staked on the flesh side, stuffed again as before, and then set out lengthwise of the flesh and grain, and hung up to dry. Tanning can also be done in a drum in much less time than in a vat or a paddle.

*Alum tannage No. 3.*—A process which is a little different from the preceding one is carried out as follows: After they are tanned with alum and salt, the sides are hung up and partly dried; but are staked while a little damp, and then thoroughly dried. They are next stuffed by being given a coat of hot tallow, applied liberally until they will absorb no more. The leather is then run in a dry drum, stretched, and after rubbing off the superfluous grease, is ready for use.

*Picker leather.*—This leather is used extensively in cotton, woolen, and silk mills, and great care must be taken in its manufacture. It must be soft and mellow so that it can be tied into knots, and above all, it should be so tough that it will not tear or rip out where loops are cut into it to fasten onto the shuttle. The hides should be from good steer selection, weighing from 50 to 60 lb. each. They are soaked in cold water in the usual way, and when thoroughly soaked, are limed. When sufficiently limed, that is to say, when the short hair can be worked out, the sides are reeled into water at 95° F. This temperature should be maintained; and the stock again reeled at the expiration of 24 hours. After remaining in this warm bath 48 hours, the hides are ready to be dehaired. Fleshing and bating follow, the hides being bated

down soft and silky. All the lime should be removed, and the hides should be soft, low, and clean, before they are put into the tan liquor.

Gambier is preferable as a tannage, since it tans quickly and makes soft leather. Oak tannage also produces a soft, tough leather. The coloring must be done in paddle-wheels. The sides must be wheeled regularly, and the liquor gradually strengthened until the stock is thoroughly tanned.

Lactic acid used in the first stages of coloring proves advantageous. Rapid tanning results, by the proper use of the acid, and plump, yet mellow leather is obtained. This method is known as the oak-bark tannage, and it is suggested that when the hides fresh from the beam-house are put into the liquor, the latter should not be over 2° bk., and lactic acid is best employed for plumping after the third day of tanning. Gambier-tanned picker leather is treated in the same manner as oak leather in the first stages of tanning, or until the grain and flesh are nicely struck through with tannin. The sides are then ready for a special treatment, which forms a yellow streak in the center of the hide.

The gambier liquor is made of about 4 per cent alum and 1 per cent salt, and sufficient gambier to give a bright orange color. This bath is heated to 90°F. At the end of an hour, draw the sides out and return them to the liquor, and in 2 hours repeat the treatment, and again in 3 hours. The following day raise the leather and put it back again, and let it remain for 24 hours, then hang it up and sammie quickly. Put the sides into a stuffing-wheel, together with all the tallow they will take—say, 4, 5, or 6 lb.—until all the tallow has gone into the stock. The sides should now be set on the machine, then re-set by hand, and given a good coat of dubbing made of tallow and sperm oil, about 60 per cent of the former to 40 per cent of the latter. The tallow should be allowed to cool until one's hand can bear the heat, or until a slight skin arises on the surface of the tallow. The sperm oil may now be added, the tallow being stirred constantly while the oil is poured in slowly. This makes a fine, close dubbing,

and both oil and tallow will penetrate. Should the oil be added while the tallow is hot, it will result in what curriers call "fish eggs," and only the oil will penetrate the stock, which is very undesirable. The leather is then dried and worked out soft and clean.

*Pyro tan.*—A process recently introduced into the United States consists of treating side leather, kips, or skins, with a solution containing aluminum sulphate, salt, and sodium pyrophosphate. The stock is de-haired, bated, and pickled in the usual manner, and is then milled in a solution, sufficient to float the hides, containing 10 lb. of aluminum sulphate, 5 lb. of salt, and 1¾ lb. of sodium pyrophosphate for each 100 lb. of stock taken. The mill is run continuously until tannage is complete, which occupies from 5 to 10 hours, according to the weight of the pelts. The leather may be finished at this point by fat-liquoring, drying-out, dampening-back, staking, etc. The usual procedure, however, is to re-tan in gambier or quebracho, and finish as indicated under vegetable tanned leather.

In working with this process, the author has found that it may be used as a pre-tannage for one-bath chrome treatment. The leather thus secured has fine body and excellent tensile strength. It may be finished as given later under chrome tannage. The author has also found that the combination may be used to advantage as a pre-treatment in the manufacture of oil-tanned lace or glove leather.

**Chamois leather.**—At the present time this is made almost exclusively from sheepskins. It is produced by the action of oil upon the raw skins, and is distinguished from all other classes of leather by remarkable softness and open texture. After the wool is removed, the skins are limed long and thoroughly; they are then split on a machine, the grains being tanned and finished into fancy leather, and the flesh splits into oil-tanned or chamois leather. The splits are de-limed, washed, and pressed to rid them of the surplus water and to make them as dry as possible.

To soften them, the skins are thoroughly beaten by a ma-

chine, after which they are sprinkled with cod oil, and again beaten to force the oil into the leather. The best grade of Newfoundland cod-liver oil is considered most suitable. Oiling and beating the skins is repeated 2 or 3 times, or until they have assumed a mustard color. They next undergo a process of heating, by which the oxidation of the oil, begun during the previous process, is completed. The heat is generated spontaneously. The skins must be watched closely and should be turned over frequently. When the temperature gets too high, the leather is seriously damaged. The highest temperature allowable is 130° F. When oxidation ceases, and the skins are no longer susceptible to heating, they are treated to remove the oil. This is done by washing them in hot water and then squeezing in a hydraulic press. The grease squeezed out in this way, is called "degras," and is used by tanners. The oil remaining in the skins is removed by washing them in a solution of soda ash, which causes the fatty acids to saponify. This saponified oil is then neutralized with sulphuric acid and forms what is known as "sod oil." A certain amount of the oil should be allowed to remain in the skins to give them softness.

The finishing process consists of staking and smoothing down all unevenness on the surface. The skins may be bleached or colored, as may be desired.

*Bleaching.*—Chamois skins may be bleached by exposing them to direct sunlight. They are first treated with 2 per cent solution of a neutral soap, then wrung out, rinsed, and exposed to the sun for a day. A second washing with a 1 per cent soap solution is given; the skins rinsed, and again exposed to the sun. This process is repeated until the skins are bleached satisfactorily. Washing may be done with soda, but this has a tendency to make the leather harsh; soap is therefore preferable.

Chamois leather is bleached rapidly and uniformly by immersion first in a solution of potassium permanganate and then in sulphurous acid. Before it is bleached, the excess of oil must be removed by washing in a lukewarm 2 per cent

solution of a neutral soap; the skins are then rinsed and wrung out. The solution is prepared by dissolving 1 lb. of permanganate in 5 pints of water. Enough of this solution is added to water in a tub to color it a deep purple. The bath is then warmed up to 100° F., and the skins are placed in it, one at a time, and stirred for 20 minutes, after which they will be found to be thoroughly permeated with the solution.

The first bath can also be prepared by using 1 oz. of potassium or sodium permanganate for each dozen skins. Then sulphuric acid to about one-fourth the weight of the permanganate is added, and the skins thrown in.

After the permanganate bath, the skins are rinsed in cold water and placed in a solution of sulphurous acid. The tub should contain water into which gaseous sulphurous acid is either conducted from a steel cylinder, or liquid acid is added until the brown color of the stock has disappeared and the skins are bleached. The goods are stirred in the acid for 15 or 20 minutes, or until they are white; they are next rinsed in cold water to remove the acid, and are hung up to dry.

Sulphurous acid may be prepared as follows: Dissolve 14 lb. of sodium bisulphite in 15 gallons of water. Into another vessel containing 2½ gallons of water, pour 6 lb. of muriatic acid, and mix well. The skins are placed in the bisulphite solution, and the diluted acid is added slowly until the skins are bleached throughout. They are then washed thoroughly, dried, and finished.

The second bath may be prepared by adding 3 per cent of sodium bisulphite to sufficient water, or about 3¼ oz. per dozen skins, and after the goods have been in the solution 15 minutes, muriatic acid, one-third of the weight of the soda, is diluted with water and added slowly to the liquor. After the skins have been bleached and washed they are washed in a solution of white castor-oil soap or olive-oil soap, and are then dried and finished by staking and pumicing.

**Rogers' shark-liver oil process.**—In his work on shark-liver oil, the author has found that this material may be used to advantage as a substitute for cod-liver oil, and in many

cases gives even better results than this commonly used product. As previously mentioned, it can be used for straight oil tannage, but a method which has given very satisfactory results is covered by U. S. Patent No. 1,346,385, granted July 13, 1920. In working with this process, the stock is depilated and pickled in the usual manner, and is then run in a drum with 7 per cent of aluminum sulphate, 5 per cent of salt, and 2 per cent of borax. When well tawed, the stock is horsed-up over night, set out, and hung up to dry. When thoroughly dry it is dipped in lukewarm water and piled down to sammie. When properly damp, the hides, splits, or skins are placed in the drum and run for 2 hours with 5 per cent of shark-liver oil. A second lot of 5 per cent of this oil is then added, and after an hour, 3 per cent more, and after another hour, another 3 per cent. At the end of the day the hides are placed in piles to temper. The following day the stock is well set out on the machine. If to be used for lace leather, the hides are given a dubbing of shark-liver oil and tallow in the proportion of 3 to 1; if for chamois leather, no dubbing is applied. In each case the stock is hung up to dry, and when thoroughly dry the stock is piled down tightly to oxidize. Care must be taken that it does not become too warm. To hasten the oxidation the skins may be slightly dampened before piling. As the oxidation reaches the limit the stock is milled in the drum or stocks, and again hung up to dry in a warm room. If lace leather is desired, the hide should be well set before drying and after drying should be rolled on the jack.

For glove or chamois leather the skins are not set out, but after drying are milled with a solution of sodium carbonate, well washed, and dried. The dried skins may then be staked and buffed, and are ready for market.

**Sheepskin fleshers.**—When sheepskins are split out of lime the grains are de-limed and tanned in bark, sumac, or some other tannage, and finished into skivers; the splits or flesh portions are made into chamois leather and used for linings, gloves, and other purposes; they are also tanned in

other ways and used for various purposes where inexpensive material is required. Any one of the alum tannages for whole skins can be used in tanning the splits. Tanned with alum, salt, egg-yolk, and flour, they make very soft stock which can be used in the white or colored any shade. The chrome process can also be used, the splits being fat-liquored, dried, and staked in the usual manner. A formaldehyde tannage can also be applied: For each 100 parts of pelt, 1 part of commercial formaldehyde in the necessary quantity of water is used. The skins are left in the liquor from 12 to 24 hours, and are then neutralized, washed, and fat-liquored with 6 parts of soft soap, thus making a very soft leather resembling chamois skin. Yellow stock is obtained by using moellon instead of soap as a fat-liquor.

*Imitation castor.*—A process for sheepskin splits, which produces stock closely resembling castor or Mocha leather, is carried out as follows, the quantities of materials being sufficient for 2 dozen fleshers of ordinary size: The goods are immersed, stirred, and pounded for 30 minutes in a solution of 1 lb. of alum, ½ lb. of flour, ½ lb. of oatmeal (or 1 lb. of either alone), ¼ pint of olive-oil and sufficient water to process nicely. Tanning can be done in a drum in about 30 minutes.

The goods are then immersed for a half hour in a solution consisting of ¼ pint of ammonia, ½ bar of soap, ½ oz. of soda, ½ lb. of salt, and 2 oz. of whiting or ocher, all boiled in 1½ gallons of water. To this solution is added either 1 lb. of flour or 1 lb. of oatmeal mixed in 6 quarts of water. The fleshers are drummed in this mixture for 30 minutes, after which they are dried, worked soft, and finished on either side. The skins dressed in this manner are very soft, pliable, elastic, and strong. After having been treated by the first part of the process, they may be dried and finished, yet it is desirable to use the entire process, as they are thus given a superior quality and capacity for a better finish.

Another excellent process is as follows: The splits, drenched and free from lime, are put into a drum together with a

solution of 12 oz. of alum and 4 oz. of salt in a half pail of water, and drummed 30 minutes. Then 1 pail of flour is added for each 10 dozen skins, and 1 quart of fresh egg-yolks, and the drum run for 30 minutes longer. Take the skins out of the drum and hang them up to dry; put them away in a dry, cool, place for a few weeks, then dampen and mill them in flour, knee-stake them, and run them on a fine emery wheel After this has been done, wash the skins, and if they seem to require it, give them 1 to 2 quarts of egg-yolk to 12 dozen skins; dry them again, and stake out soft. The finished skins should be very soft and white. They can also be colored any shade desired.

**White calfskin leather.**—Soft, tough white leather is made by tanning calfskins by the following process: The skins are limed, bated, and pickled in the usual manner and are then allowed to drain 24 hours.

*Tannage.*—To prepare the tanning liquor boil 12 lb. of aluminum sulphate in 10 gallons of water. Dissolve 24 oz. of bicarbonate of soda in a pail, and pour the solution slowly and with constant stirring into the sulphate solution. Allow the resultant white liquor to cool to 80° F. Put the pickled skins into a drum, together with 10 gallons of water, 1 lb. of Glauber's salt, and 3 lb. of common salt for 100 lb. of skins. Drum the skins 20 minutes with the solution, then drain off the liquor. Put 10 gallons of lukewarm water and 6 lb. of salt into the drum together with the skins, and let the machine rotate 10 minutes. Then pour half of the sulphate-soda solution into the drum, and drum the skins 3 hours. At the expiration of that period, take the leather out and let it drain until the next day; then hang it up to dry. When dry, put the skins back into the drum, together with 8 gallons of water, and run them 10 minutes; then add the rest of the white liquor and run the drum 2 or 3 hours. Place the leather over horses to drain at least 12 hours, then hang up to dry.

*Fat-liquoring.*—When dry, let the leather lie in the crust state in a clean dry room for some time, the longer the better;

then dampen it with warm water preparatory to fat-liquoring. Sulphonated castor oil or acid fat-liquor is the material to use, as it imparts softness without discoloring the leather or making it greasy. For each 100 lb. of dry leather use 7 lb. of the oil, and stir it into 10 gallons of water at 95° F.

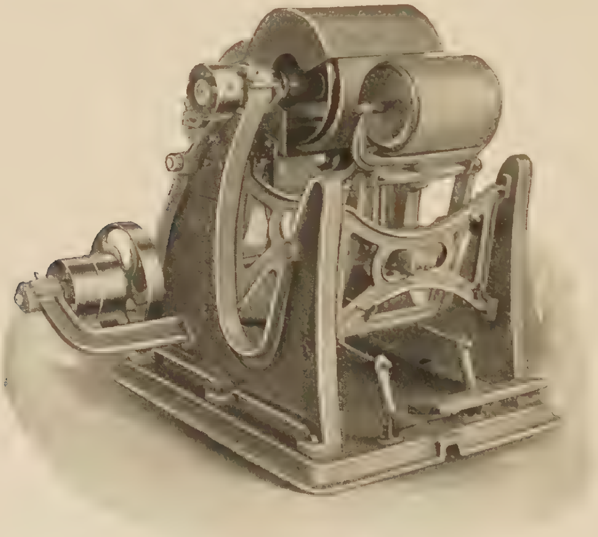

**Figure 58.—Buffing machine, used for snuffing grain for ooze, and flesh for suede leather.**

until it is dissolved. Put the moistened leather into the drum; start the machine, and pour the solution of oil through the gudgeon, and drum the leather 40 minutes; then let it drain over night. The next day strike out the grain and apply a mixture of French chalk (talc), 2 parts of glycerine, and 4 parts of water. Apply this to the grain and then hang the leather up to dry.

*Finishing.*—This process consists of moistening the leather, staking, and tacking it on boards. If it is not soft enough when dry and taken from the boards, re-stake it; if staking does not soften the leather sufficiently, wet it and give it more fat-liquor. The appearance of the flesh can be improved by buffing on a carborundum wheel (figure 58); and the leather

can be finished on the flesh if such flesh-finished leather is desired

Another process of making white calfskins employs an alum tannage composed of aluminum sulphate, salt, flour, egg-yolk, and oil. The proportions given are based on 100 lb. of pickled skins. Make a paste of 5 lb. of flour and a little water. Dissolve 3 lb. of sulphate and 5 lb. of salt in 10 gallons of water. Slowly add 4 oz. of bicarbonate of soda, and then mix in 2 lb. of egg-yolk and 2 lb. of olive oil. Add the flour paste and drum the skins 3 hours in the mixture. Leave in the liquor over night, drum a few minutes the next morning, and dry at a moderate temperature.

Finishing consists of staking and buffing the skins, drumming them with 1 lb. of egg-yolk and 5 lb. of talc; then setting out, tacking, and drying. If colored leather is desired, the grain can be colored by hand, leaving the flesh white; or a drum can be used and the leather dyed throughout. This class of leather is, as a rule, dyed with wood colors, which may be shaded with acid colors. Another method is to bottom the leather with wood colors and then top with basic colors.

*Formaldehyde tannage.*—By a method of tanning with formaldehyde, white skins are obtained which are very similar to alum-tanned goods. The beam-house processes are carried out as usual; the skins are next washed in tepid water, when they are ready for the tannage. For this a solution of 2½ parts of commercial formaldehyde in 100 parts of water is used. This liquor is prepared in a paddle, and the skins are put in and left there from 24 to 48 hours; then withdrawn, neutralized, washed, and fat-liquored with a liquor made of 100 parts of neat's foot oil, 25 parts of carbonate of soda, and 500 parts of water. The skins are drummed in this for an hour, then dried and finished. Sulphonated oil can be used for fat-liquoring, with good results. Fat-liquoring with moellon degras gives skins of a light yellow color.

*Kid glove leather.*—The tanner who wants to make Mocha

or castor glove leather will find the following process satisfactory: The skins, after they have been soaked and softened, are fleshed and limed. Liming should be done in clean white limes containing no red arsenic or sodium sulphide. The first lime should be clean, white, and weak, the skins being passed from it into stronger lime and limed thoroughly; or

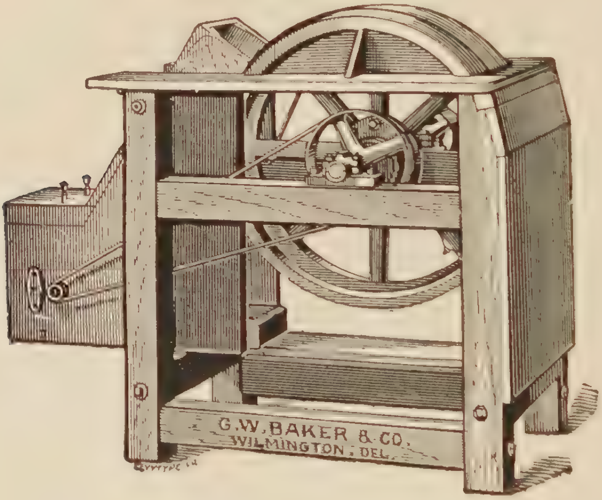


Figure 59.—Buffing wheel.

a gathering lime may be used by hauling the skins out each day and adding fresh lime The period in the lime varies from 20 to 40 days according to the judgment of the tanner. When the hair comes off easily, the skins should be de-haired and the grain frizzed. After frizzing, put the skins in weak lime water for 2 or 3 days, then wash them in warm water and drench with lactic acid in a drum, 100 skins requiring about 1 quart of acid in 10 pails of water at 90° F. Drum the skins in this solution for an hour, and rinse.

Another process, using alum, salt, egg-yolk, and flour is as follows: For each dozen skins dissolve 12 oz. of alum and 4 oz. of salt to make 1 pail of liquor, and drum the skins with this solution for 30 minutes; then add 1 pail of flour for each

10 dozen skins and 1 quart of fresh egg-yolk, and drum the skins 30 minutes longer. Take them out of the drum and hang them up to dry. When dry, put them away in a dry, cool place for a few weeks to give them time to become completely tanned. To finish the skins, dampen and mill in flour, next knee-stake them, dry again, and then run them on a fine emery wheel. After this has been done, wash them with water and give them 2 quarts of egg-yolk to 12 dozen skins. Then dry them again, knee-stake and finish on the finest emery. The skins should now be very soft, dry, and white, and can be used for white gloves without further treatment. If colored skins are desired, they can easily be colored any shade, then dried and staked, and finished on a buffing wheel, as shown in figure 59, using the finest emery. This process can also be used for grain-finished skins. For such goods, however, it is best to use arsenic with the lime and a dung bate to de-lime the skins. The leather finishes soft and strong, and has a fine appearance.

Another good formula for pickled sheepskins which produces nice white, soft, and "well-fed" leather is as follows; For 1 dozen skins, 1 lb. of alum, 1 lb. of salt, $\frac{3}{4}$ pint of egg-yolk, and 1 lb. of flour are used. The alum and salt are dissolved in hot water. The flour is mixed with cold water, the egg-yolk is added, and the whole is thoroughly stirred. The solution of alum and salt and the mixture of egg-yolk and flour are put into the drum together with the skins, and the whole drummed for 2 hours. The skins are left in the liquor over night, then dried out. One to two gallons of warm water are used with the tanning materials for 1 dozen skins. This tannage should not be used on skins in the pickled condition, but if such skins are to be tanned with it, the pickle should be removed by a light sour drench of bran and salt, or bicarbonate of soda and salt.

One dozen small lambskins for glove leather can be tanned with $\frac{3}{4}$ lb. of alum and $\frac{1}{2}$ lb. of salt. Dissolve the alum and salt together, making a half pail of liquor. Drum the skins with this solution for half an hour: then add 1 pail of good

flour to each 10 or 12 dozen skins, and 1 quart of egg-yolk. Run the drum a half-hour longer, then hang the skins up to dry. After drying, lay away for a while to age. Next dampen the skins and drum with a little flour, then knee-stake them (figure 60), wash, and give them 2 quarts of egg-yolk to 12 dozen skins. Dry again, stake, and finish. The skins should be taken from the drench and tanned without pickling. If pickled, drench them in sour bran or bicarbonate of soda to remove the acid.

**Figure 60.—Knee-staker.**

Sheepskins taken from the drench or de-pickled in a bath of sour bran and salt can be alum-tanned in the following manner: For every 100 lbs. of skins, 3 lb. of aluminum sulphate and 6 lb. of salt are dissolved in 6 gallons of water. This liquid is put into the drum with the skins, and the drum is run 30 minutes. A solution of 10 lb. of sodium hyposulphite in 5 gallons of warm water is poured into the drum, and the skins are drummed in the combined solutions for 20 minutes. The hyposulphite fixes the tannage on the fibers of the skins, and also thins the goods. In order to overcome this thinning, another solution of 2 lb. of aluminum sulphate and 4 lb. of salt in 3 gallons of water is added to the contents of the drum, and the drumming is continued for another half-hour, or until the skins have become plump. The next operation is rinsing in clean water and allowing the leather to drain several hours, then drying it out. Skins of fine texture and grain are obtained by this process. It is very essential, however, that the skins be entirely free from acid and perfectly neutral when the process is begun, otherwise they will be imperfectly tanned. After the skins have dried, they may be made softer by drumming in a warm solution of sulphonated oil. Flour may be added to the oil. The leather

can also be washed back and tanned with a one-bath chrome liquor, and finished in any manner desired. White chrome leather is secured by bleaching the skins with borax and sulphuric acid, and fat-liquoring with sulphonated oil and flour.

Alum-tanned skins should be buffed on the flesh side on an emery-wheel to get rid of all loose flesh and make them soft and smooth. In any alum process, flour increases the softness and plumpness of the skins, and makes the grain less liable to crack. The cost of tanning is of course increased by using flour, but the better quality of the leather is sufficient to offset the added expense.

**White pigskins.**—If white pigskin leather is required, the skins should be tanned in an alum and salt tannage or with aluminum sulphate. It is also practicable to tan them with formaldehyde, as with calfskins. The white leather can be finished in the white and can also be easily colored light and fancy shades. Thorough work in the beam-house is important for such leather. Not only must the skins be soaked in sal-soda water and worked over the beam to rid them of as much grease as possible, but they should also be fairly heavily limed and bated, and then worked out again so as to be as clean as possible before tanning is started. If they are not too full of holes, pickling and tanning can be done most advantageously in a drum. To pickle 100 lb. of pigskins, use 1 lb. of sulphuric acid, 15 lb. of salt, and 15 gallons of water, and drum the skins in this liquor 1 hour; then place them over a horse to drain 12 hours before tanning.

Prepare the tan liquor by boiling 12 lb. of aluminum sulphate in 10 gallons of water. In a pail dissolve 1½ lb. of bicarbonate of soda by boiling in 1 gallon of water. Pour the soda solution slowly and with constant stirring into the sulphate solution; care must be taken to pour the soda solution in carefully, for if it is added too rapidly the tan liquor will be spoiled. The mixture should be used cold.

Tanning is effected as follows: Put the pickled skins into a drum, together with 10 gallons of water, in which 1 lb. of Glauber's salt and 3 lb. of common salt have been dissolved,

these quantities being used for 100 lb. of skins. Drum them with this solution 20 minutes; then stop the drum and drain off the liquor. Put the plug back, and throw in 10 gallons of water at 75° F., and 40 lb. of salt; start the drum and run it 15 minutes. At the end of this period, pour half of the sulphate-soda solution into the drum and run 3 hours. Drain the skins over a horse until the next day, and then hang them up to dry. When dry, put them back into the drum, together with 8 gallons of water and run 10 minutes; then add the other half of the sulphate-soda liquor and run the skins in it 3 hours. Drain them 24 hours, wash in clear water, and fat-liquor with acid fat-liquor. Drumming the skins with flour is another way to make them white. The leather is washed after tanning and then given the flour treatment; about 50 lb. of flour made into a thin paste with water being required for 100 or more skins. The leather is drummed 2 hours in the flour, and is then fat-liquored and dried.

Finishing consists of staking the leather and milling it with powdered chalk or soapstone, after which it is ready for use. The flesh should be buffed clean and smooth, and if a leather without a grain is wanted, the grain should be removed either in the beam-house or by buffing on an emery or carborundum wheel.

**Tanning snake skins with alum and salt.**—The skins of snakes, like all other skins, should be soaked in water until they are soft, then broken or fleshed on the beam, and put back into the water for a few hours. They are then pickled with sulphuric acid and salt after which they are placed in a solution of equal parts of alum and salt, in which they remain over night or longer. A basic solution of aluminum sulphate, as described for alum-tanned sheepskins, may be used for tanning. The skins are hung up to dry, and then are run with moist sawdust until all the scales are off; they are then worked out carefully and dried. Some tanners prefer to remove the scales by liming in the usual manner.

**White splits.**—Where a soft white split is wanted, a tan-

nage of aluminum sulphate may be used. If the sides are split out of the limes, the splits should be bated and pickled with sulphuric acid and salt as with grains or whole hides; they are then in condition to be tanned. The tanning liquor is prepared and used as under white pigskins.

Finishing consists of drumming the splits with a solution of sulphonated oil, 7 lb. being used in 8 gallons of warm water for 100 lb. of dry splits. Some flour may be added with advantage to the oil solution. When the leather has dried again it is staked and run in a dry mill until it is perfectly soft. The solution of oil may be added to the tanning liquor, which saves the labor of the extra fat-liquoring.

Formaldehyde also produces white leather. The splits are tanned in a formaldehyde liquor as with grains and sheepskins, then neutralized and fat-liquored with soft soap or sulphonated oil, dried, and finished.

**Splits for white shoes.**—For sporting and athletic shoes, seal splits are frequently sold as a good imitation of the real deerskin article. These goods are treated as already described so far as soaking, liming, bating, and drenching are concerned. Only the best and stoutest splits are selected for this purpose. After drenching, the splits are washed in warm water and placed in a pickle made as follows: For every 100 lb. of splits, thoroughly dissolve 20 lb. of alum and 14 lb. of salt. Use at 95° F., and drum the goods with it one hour. Then add a mixture of flour, egg-yolk, and china clay, made as follows: Mix 35 lb. of flour with enough water at 95° F. to form a fairly stiff paste, and add ½ gallon of egg-yolk and about 5 lb. of clay. No oil or grease is necessary, as seal splits are naturally greasy.

To apply this dressing it is best to stop the mill and add about half of the paste to the goods. Drum 15 minutes, then add the remainder of the paste, and run 2 hours. Next take the splits from the mill, double them across, and spread them out in a vat or tub. The liquor in the mill is then poured over them and they are allowed to lie in this for 3 days, hauling up once a day and allowing to drain. After the final

draining, tack on frames or boards and dry quickly. If this is not done the result will be poor, as the alum and salt will not be fixed properly, and the finished leather will be flat and tinny.

The splits are now allowed to lie in a cool place for 2 or 3 weeks to feed and mellow, and they are then staked. Damp down first by draining through the liquor they are in, after making up a convenient quantity with water. Stack them in a pile until they are in good condition for staking, which is best done by hand, although machines do good work. The splits are then dried and worked on the perch with the arm-crutch stake. Next carefully run them on an emery wheel, commencing at the butt and work about halfway across, and then turn them and do the other side in the same manner. Turn over, and repeat the operation as before, and a fine, velvety fiber will result. After being again placed in the perch, rubbed over with whitening, and finally worked out well with the hand-scouring tool, the splits are ready for the shoe manufacturer.

**Tanning buckskins.**—The preparatory treatment of deer-skins is somewhat similar to that for sheepskins. Green skins are soaked for a few hours and fleshed. As they are very buoyant and will not stay under the water, it is necessary to place a weight on them to keep them submerged. For dry skins a sulphide soak should be used and the skins thoroughly softened before they are put into lime or coated with depilatory paint.

Two methods can be followed for removing the hair: The skins may be painted with a mixture of lime and sodium sulphide, or one of lime and red arsenic, as for sheepskins; then de-haired and limed a few days. Another method is to place the skins in lime as for calfskins, using lime and sodium sulphide; de-hairing in the usual manner, and then bating the skins.

De-liming is effected by bating or drenching the skins with the same materials used in de-liming sheepskins; the goods then pickled and tanned.

**White buckskin.**—A well-tanned, soft, and white buckskin is obtained by tanning with a solution of basic aluminum sulphate, as under white pigskins. Dampen, stake, and dry the goods, then buff and drum with 2 lb. of egg-yolk or sulphonated oil and 5 lb. of talc. Set the leather out, tack, and dry. Any shade of color—gray, tan, etc.—can be obtained by ordinary application of suitable wood dyes or artificial dye-stuffs.

A white leather is also made by tanning the skins with formaldehyde; and by adding a little moellon of the first quality to the soap fat-liquor, very supple skins of a light yellow color are obtained. Neat's foot oil and cod oil, as well as sulphonated oil, produce white skins. The skins are left in the liquor from 24 to 48 hours, when they are neutralized, washed, and fat-liquored with soap for white leather; or with soap and moellon, or moellon alone, for a yellow shade.

Where the grain has been removed, the skins tan rapidly. The leather resembles alum-tanned goods, being of good white color, soft, and supple. Sulphonated oil serves as a fat-liquor; so does soap and moellon. Finishing consists of staking and working out.

**Indian method of tanning buckskins.**—The North American Indians have for ages dressed deerskins into leather, and the leather made by them is renowned for toughness and durability. A description of their method of dressing is of interest:

According to John Motheral in the "Leather Manufacturer," the skins are fleshed and all flesh and membrane removed. It is then soaked in water to swell and free it from blood, when it is ready for graining, which is done with a case-knife or a butcher's knife on a beam having a diameter of 6 or 8 inches. This way of removing the hair and the grain makes Indian-dressed buckskin of the highest class.

Another way of preparing the skin for graining is, after the skin has been fleshed and soaked, to treat it with a weak lye for 2 or 3 days, and then grain it. But this does not yield a product equal in toughness to that by the former

method. The skin being grained, is then ready for the tanning or tawing process, which is done with the brains of the deer or those of cattle, horses, hogs, etc.

Briefly, the brains are prepared by putting them into a bag of loosely woven cloth, and boiling them an hour in soft water. The water is then poured off into another container, and cooled until one's hand can bear the heat. The bag is rubbed between the hands under this water until the brains are forced through the cloth. The buckskin is then kneaded and stretched in the liquor for an hour, at intervals of 10 minutes; and is allowed to soak for 2 hours (over night in winter) followed by more kneading and stretching. The skin is then partly dried, after which it is stretched every way until dry, folded, wrapped, and put away for 2 weeks or more. The skin is now ready for the smoking process, which colors and re-tans it, bringing it into condition whereby it may be washed with soap, yet it dries soft. Smoking is done with a slow fire of decayed wood, and is continued on both sides until the color is light yellow to yellowish-brown. The Indian stretches the skin over the end of a barrel, and conducts the smoke to it; but a smoke-house, such as used for curing meat, will do as well. After being smoked, the skin is scoured with soap in lukewarm water, rinsed, dried for a week, dipped in water for a few seconds, folded, and covered for a half day, stretched, and dried. The skin is then soft and pliable.

**Tanning with formaldehyde.**—By the application of the following process of tanning hides or skins, a leather is obtained which will not lose its tannage through the action of hot water or sweat. It is also very tough and resistant to tension, being especially adapted for orthopedic and surgical uses, such as belts, straps, linings, envelopes, gloves, and even for saddlery and shoemaking.

The leather is prepared by a combined tannage of formaldehyde, grease or oil, and a watery emulsion containing magnesium silicate. This emulsion contains the active parts in extremely fine division, in order to favor as much as possi-

ble the contraction and binding of the surface. The skins are prepared in the usual manner by liming, bating, and washing, and are then placed in the drum, together with the emulsion, which must be sufficient to cover them.

The tanning can also be done in stationary tanks, but this takes more time. At the beginning, the emulsion is composed preferably of 20 per cent oil, 5 per cent talc and $\frac{1}{4}$ per cent formaldehyde. A durable fat emulsion is first prepared for which any of the water-soluble (sulphonated) oils may be used. The addition of gum tragacanth or similar binding substances to the emulsion is not absolutely necessary, if care is taken to neutralize the small amount of free oleic acid present in the oils, by adding about 10 drops of soda solution to each quart of the emulsion. About one or two times the quantity of formaldehyde given, as may be required, is added in the course of the tanning. The length of time needed to tan the skins depends upon their thickness. Several days are required for thin leathers where stationary tubs are used; thick skins require from 2 to 3 weeks. Where a drum is used, thin skins can be tanned in 24 hours.

All kinds of skins can be tanned by this method; and it may, either before or after tanning, be used in combination with any other tannage. Leather made by this process differs from chamois in its color and greater strength, and it does not shrink even after repeated washing.

This leather, which is similar in appearance to tawed leather, maintains—even when 3/16 inch and more thick, perfect pliability and suppleness, together with great firmness, which enables it to fit itself wherever worn.

# CHAPTER VI

## CHROME TANNAGE

The action of chromium salts upon hide substance was first studied by Knapp in 1858, but his investigations led him to conclude that their application was of no practical value. Although other investigators took up the matter, it was not until 1884 that any really important advance was made. At this time Augustus Schultz patented his "two-bath process," in which skins or hides are treated with a solution of chromic acid, produced by the action of hydrochloric acid on sodium or potassium dichromate, and afterwards with a solution of sodium thiosulphate and hydrochloric acid. The hide substance takes up the chromic acid, which is subsequently converted to the basic condition by means of the "hypo." In 1893, Martin Dennis made a study of the action of chromium salts as previously investigated by Knapp, and perfected a method for "one-bath tannage," for which he was granted numerous patents.

**Two-bath chrome process.**—While the details involved in the application of this process vary, nevertheless chrome tanning is uniformly carried out either in a paddle or drum. Different kinds of leather require different percentages of the chemicals. In the drum tannage, 6 per cent of sodium dichromate and 3 per cent of hydrochloric acid, regulated on the weight of the wet skins, are mixed with sufficient water for the proper handling of the stock. The skins or hides are placed in the drum, and the chrome solution is added, while the drum is kept in motion. The hides or skins are worked in the solution until they have taken on a uniform yellow color and are completely struck through. They are now removed from the drum and freed from the superfluous liquor either by horsing up over night or by putting out; the latter operation may be done by hand or on the machine. After standing for 24 hours, the chromed stock is returned to the

drum and run for about $1\frac{1}{2}$ hours with a solution of 12 per cent of sodium thiosulphate and 6 per cent of hydrochloric acid. On removal from the drum the stock should have a blue-green color and should be uniform throughout. If thoroughly tanned, no curling will take place when a strip is placed in boiling water. The stock is horsed up for 24 hours to allow the chrome to set. It is then neutralized by running for 30 minutes in a $\frac{1}{2}$ per cent sodium bicarbonate solution, washed in running water 30 minutes, horsed up, and allowed to drain.

The reactions taking place in this process are represented in the following equation:

$$Na_2Cr_2O_7+2HCl=2NaCl+2CrO_3+H_2O$$

The $CrO_3$ produced forms a compound with the gelatine. The sodium thiosulphate now acts as a reducing agent upon the chromic oxide, converting it from the acid to the basic condition, the reaction taking place in two stages. The basic chromium chloride held by the fiber is probably converted largely to $Cr_2(OH)_6$ by the action of the sodium bicarbonate used in washing.

**One-bath chrome process.**—In this process the skins or hides, after coming from the puer, are washed with running water and run in a pickle for about 1 hour. The pickle is made by dissolving 8 lb. of salt and 2 lb. aluminum sulphate in a small quantity of water, adding 1 lb. of sulphuric acid, and making up to a density of 40° bk. The object of this treatment is to neutralize any remaining alkalinity of the puer or lime, and to ensure the stock being in an acid condition before it enters the tan.

One-bath chrome liquor is made in many ways. A good solution may be made by dissolving 10 lb. of sodium dichromate in 10 gallons of water, adding 6 lb. of syrup glucose (40° Bé.), and then slowly introducing 10 lb. of concentrated sulphuric acid. A wooden vessel should be used for making up this liquor. A less violent action, however, is produced by adding the glucose last, but in this case stoneware or other acid-resisting vessels must be employed A liquor, when pre-

pared as above and diluted to 45° Bé., will give a product of such strength that 15 lb. will be required for each 100 lb. of pickled skins treated.

In using this method, the necessary amount of reduced liquor (15 per cent of above liquor, equivalent to 4 per cent of dichromate) is dissolved in a sufficient quantity of water for proper handling of the stock, and 5 per cent of sodium sulphate added to the solution. The pickled skins are placed in the drum, the door is closed, and one-third of the solution introduced while the drum is in motion. At the end of 15 minutes another third is added, and in 30 minutes the remainder. A half-hour after the last portion has been put in, $\frac{1}{2}$ per cent of sodium bicarbonate in solution is added, and the stock run for 15 minutes longer, or until tanned. The hides or skins are then removed from the drum, horsed up over night, neutralized with $\frac{1}{2}$ per cent of sodium bicarbonate, thoroughly washed, horsed up again, and allowed to drain.

The reactions taking place in the above liquor are as follows:

1. $Na_2Cr_2O_7 + H_2SO_4 = Na_2SO_4 + H_2Cr_2O_7$
2. $H_2Cr_2O_7 + H_2O = 2CrO_3 + 2H_2O$
3. $2CrO_3 + 6H$ (reducing agent) $= Cr_2(OH)_6$
4. $Cr_2(OH)_6 + 2H_2SO_4 \quad CR_2(OH)_2(SO_4)_2 + 2H_2O$

The basic chromium sulphate thus formed is the tanning agent, and is decomposed by the hide substance into $Cr_2(OH)_6$ and $Cr_2(OH)_4SO_4$ with the liberation of free sulphuric acid. This free acid must be neutralized with some mild alkali such as borax or sodium bicarbonate to complete the tannage, otherwise a reverse action is likely to take place.

The resulting tannage is the same whether a one or two-bath method be employed.

Chrome tannage by either of the processes given above may also be carried out in the paddle, but in this case the time of treatment is somewhat longer. The advantage of the paddle tannage is that a smoother grain is obtained with less danger of "pipey" leather.

To understand the process of chrome tanning better we will take up its application to the various grades of stock:

**Glazed kid manufacture.**—As previously shown, goatskins come to the tanner from many different countries, where they are cured, in many various ways, such as sun-dried, dry-salted, wet-salted, clay cured, etc. The first duty in preparing these skins for manufacture is to classify them and cure into different sizes and weights, namely, "bulls," "heavies," "large," "regulars," and "kids"; and for quality into "firsts," "seconds," and "culls."

The selected skins then pass to the first manufacturing process, which is called "soaking," where the skins are placed in tanks of fresh water for about 24 hours to become thoroughly soaked for the milling process. The skins are then placed in large revolving drums with protruding wooden pins inside, and milled in running water for several hours to beat up and soften the skin to bring it as near as possible to the condition of a green skin, as it was when taken from the animal.

The skins are then trimmed to remove what is termed the false weight, such as heads, shanks, and rough edges, which cannot be worked into leather. Then they pass to the liming process, where they are allowed to remain for 12 to 14 days.

On being removed from the lime liquor, the skins are unhaired by machines, and then thrown into wash-reels with running water to wash out the lime, leaving a clean, solid pelt. They then pass through a machine to clean off the superfluous flesh and fat which is not a part of the skin substance from the flesh side of the skins. Then they are subjected to the depleting process, called "puering," to render them free from any trace of lime, and to make them soft and open for the proper action of the tanning agents.

After puering, the skins are again thoroughly washed in "twisters" in warm running water. These twisters are large, square, perforated boxes, mounted to revolve on their opposite corners, which gives a twisting motion to the skins as they are thrown from one side to the other. The beam-house work

has now been done. The dry, hard skin has become a clean pelt, free from hair and dirt, with flesh and fat removed, and is soft and open for tanning.

Most glazed kid is tanned by the two-bath chrome process.

Figure 61.—Tan-room in a goatskin tannery. The operation is carried out either in paddle or drum as shown.

The first bath is a solution of sodium dichromate and hydrochloric acid; the second bath is a solution of sodium hyposulphite and hydrochloric acid. Both of these processes are performed in what are called reels as shown in figure 61, made similar in shape to a half drum, but on the inside a paddle is mounted, which engages the liquor within the reel, and keeps the liquor and skins in motion. Great care is taken to have the exact proportions of the chemicals to the quantity of water, and the weight of skins to each reel. When these operations are finished, the product is a perfectly tanned leather, insoluble, and unaffected by boiling.

After being taken from the tan liquor, the skins pass through what is called a "striking-out machine," to expel the

excess tan liquor so that they can be easily handled in the next process, which is called shaving. This work is also done by machine, (figures 62 and 63), and consists in cutting down the heavy parts of the skin to give a uniform thickness. The

**Figure 62.—Line of shaving machines used for producing a smooth effect on the flesh side.**

skins are now at a point where it is decided into what color they are to be finished, and they are sorted accordingly. The finest-textured and finest-grained skins are selected for browns and other colors, and the remainder are held for black stock. In many factories only black glazed kid is made, in which case this selection is unnecessary.

**Two-bath chrome on pickled sheepskins.**—1. The bated or pickled stock is weighed and placed in the mill, the door closed, and the following solution prepared, estimated on the weight of the stock:

| *Chemicals* | *Per cent* |
|---|---|
| Sodium dichromate | 6 |
| Salt | 4 |
| Hydrochloric acid | 3 |
| Water, 5 times the weight of the stock. | |

The mill being in motion, this solution is introduced through the trunnion, and the stock turned for 1½ hours, or until struck through. The skins are removed from the drum and horsed-up over night to allow for draining and fixation of the chrome.

*Sodium thiosulphate bath.*—On the following morning the

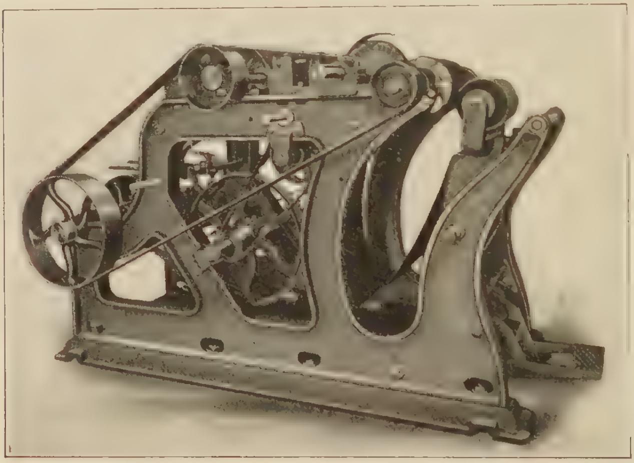

**Figure 63.—Shaving machine.**

skins are removed from the horse one at a time, dipped in a 10 per cent solution of sodium bisulphite, and thrown into the drum. The following solution,

| *Chemicals* | *Per cent* |
|---|---|
| Sodium thiosulphate (hypo) | 12 |
| Salt | 3 |
| Hydrochloric acid | 6 |
| Water, 5 times the weight of the stock. | |

is added through the trunnion while the mill is in motion and run for 1½ hours, or until a robin's-egg blue color shows. The skins are again horsed-up over night.

*Neutralizing.*—The skins, after standing over night, are returned to the mill and run for a half-hour with ½ per cent sodium bicarbonate and water equal to 5 times the weight of the stock. The plugs are now drawn, and the stock is washed

for a half-hour with running water. The skins are then set out and shaved.

2. The bated or pickled stock, having been weighed, is placed in the drum and the following solution prepared:

| *Chemicals* | *Per cent* |
|---|---|
| Sodium dichromate | 6 |
| Sulphuric acid | 2 |
| Salt | 4 |

with the necessary amount of water to give proper working conditions. The skins being on the shelf, the solution is placed in the bottom of the drum, the door is closed, and the drum is started. The turning is continued for about 1½ hours, or until the stock has become struck through. It is then horsed-up over night and allowed to drain. The next morning the skins are returned to the drum with a solution of 6 per cent sodium bisulphite, mixed with sufficient water to float the stock. They are treated in this reducing solution for about an hour, or until a robin's-egg blue color shows. The stock is again horsed or piled for 24 hours, to allow hydration to take place. To neutralize the excess of acid, run the stock with ½ per cent of sodium bicarbonate, and finally wash well with running water.

**Tanolin.**—The pickled stock is placed in a drum with 6 lb. of salt and 8 gallons of water for 100 lb. of stock and drummed 15 minutes. Six pounds of "tanolin," dissolved in 2 gallons of boiling water, is the tanning material used, and it is divided into three parts. One part is poured into the drum, and the stock run for 30 minutes; the second part is then added, and the machine run 30 minutes; then the last part is added and the drum is run an hour. Eight ounces of bicarbonate of soda is dissolved in a little water and poured into the drum, and an hour later another 6 oz. is dissolved and added and the skins are drummed another hour. They should then be completely tanned. When removed from the drum, the skins should be horsed-up and allowed to drain 24 hours. They are then washed and neutralized.

**One-bath chrome on pickled sheepskins.**—This consists of first tanning them with aluminum sulphate and salt and then tanning with chrome liquor. When this process is used it is necessary to remove the acid from the skins. This is done by stirring them for a few minutes in a warm drench of sour bran and salt or bicarbonate of soda and salt. They are then in condition to receive the sulphate and salt.

The usual formula for the preliminary tanning is 3 lb. of aluminum sulphate and 6 lb. of salt for 100 lb. of skins. These materials are dissolved in 6 gallons of warm water and the skins are drummed in it 30 minutes. The sulphate does not act as a tanning agent in this process, as it is washed out before the leather is dried. It serves to plump the skins and prevent contraction of the grain and fibers by the astringent chrome liquor. After the skins have been drummed with the sulphate and salt, 3 gallons of concentrated chrome liquor, diluted with 3 gallons of warm water, are poured into the drum in portions of 2 gallons at intervals of 30 minutes, and the drum is run for 2 or 3 hours or until the skins are tanned through. They should then be left in the liquor over night so that the chrome salts may take full effect on the fibers. The next day the tanned leather is washed and shaved in the usual manner.

Pickled sheepskins may be tanned into plump, well-tanned leather in the following manner: Dissolve 3 lb. of aluminum sulphate and 3 lb. of salt in a few gallons of boiling water, and add enough cold water to make 10 gallons of solution. To this add slowly 8 oz. of bicarbonate of soda dissolved in a little hot water. Drum the skins with this liquor one hour, then hang them up to dry. When they are dry, wet them back and tan them with one-bath chrome liquor in the usual manner. The tannage is complete when a piece of chrome leather remains soft in boiling water; imperfectly tanned leather hardens and curls in boiling water.

*Process for glove leather.*—The following method of handling pickled sheepskins for glove leather, although called a two-bath process, is really a three-bath process. The skins

are not taken from the drum until they are fully tanned, when they finish out into soft, durable leather.

The pickled skins are given a fairly strong re-pickle so that the grease will run well, and are pressed or wrung until as much of the natural grease as possible has been extracted. They should then be drummed in a salt solution until well broken up. Care should be taken, after the skins have started in the press, to keep the pressure steadily increasing. They are horsed-up from the salt solution and allowed to drain before weighing. The skins are next weighed and thrown into a drum, and 1 per cent of salt is put on them, and 3½ to 4 per cent sodium dichromate is dissolved in 10 gallons of water for 100 lb. pickled weight. This should be fed in two parts. The skins are drummed in this from two to three hours. This will be a short liquor, but for the leather desired it works well.

The next step is to put 3½ per cent sulphuric acid in 10 gallons of water for each 100 lb. of skins, and 4 lb. of salt for 2 lb. of acid. This is fed through the gudgeon and the skins are drummed with it for 20 minutes. Then 12 lb. of sodium hyposulphite are dissolved in 12 gallons of water for 100 lb. of stock, and the solution is fed to the skins and drummed for 2 hours; this completes the tannage.

The leather, after it has been horsed-up 12 hours, is washed, neutralized, and then fat-liquored. If it is to be finished in the pearl or regular chrome color it should be given 2½ per cent white chip soap boiled and made up to 10 gallons for 100 lb. of leather, and drummed 20 minutes, and then given 5 per cent of egg-yolk. Horse-up and allow to drain 24 hours, and hang up to dry in a moderate temperature; then drum the leather in warm water until it is thoroughly wet through, set it out, and hang it up again. Finishing is done by staking on the machine, dry drumming with talc, and staking again.

If it is desired to make colors, the fat-liquoring would necessarily have to be done without the soap, and the skins would be colored with suitable dyestuff and handled in the finishing as regular chrome leather.

**Neutralizing and washing chrome sheepskins.**—In every

case of chrome tannage it is necessary to drain the leather over horses or on smooth piles for 12 to 24 hours before proceeding to wash and neutralize it. This is done to allow the chromium hydroxide to become dehydrated and fixed in the fibers.

The most efficient neutralizing substance for chrome leather is bicarbonate of soda. From 1 to 3 lb. is used for 100 lb. of leather. It is dissolved in 10 gallons of warm water, and the leather is run in the solution 30 minutes. The plugs are next pulled out and the leather is washed another half-hour with running water; it is then set out, or pressed and shaved. Some tanners shave their leather before they neutralize it. Borax is also often used for neutralizing skins. Less is used, but in the same manner as soda.

**White chrome-tanned sheepskins.**—For some purposes, such as suspender trimmings, baseball covers, linings, etc., a soft white leather is required. The alum tannage can be used, but there are also special tannages which produce such leather. It is also practicable to take chrome-tanned skins, and by a treatment with flour and bleaching with borax and acid, finish them into soft, white leather. The tannage is the same as for any other chrome leather. After the leather is fully tanned it is washed and bleached. For each 100 lb. of skins, use 1 lb. of borax or bleaching soda dissolved in hot water, and wash the skins 20 minutes. Then drain out the water, replace the plug, and put cold water to which some sulphuric acid has been added into the drum, and run the leather with it 30 minutes. The borax opens and softens the skins and prevents the acids from doing injury. After the leather has been washed in the acid solution it should be washed in clean warm water, and then shaved. The next process is the treatment with flour, 50 lb. being used for 100 large skins or 200 small ones. The flour is stirred into 10 or 12 gallons of water for 100 lb. of skins, and the leather is drummed in the liquor 2 hours; it is then struck out, pressed, and given some fat-liquor. For some purposes the skins work out sufficiently white without the borax and acid treatment. Sulphon-

ated oil dissolved in warm water is excellent fat-liquor for these skins.

When the leather is dry it is moistened and staked, then run in a clean, dry drum with powdered chalk or soapstone for one hour and then arm-staked. Chrome skins in the natural greenish-blue color of the process are obtained by simply washing, shaving, and fat-liquoring them; then drying, staking, and tacking on boards.

*Tanning in a paddle-vat.*—Where the skins are tanned in a paddle-vat the procedure is as follows: The first bath consists of 6 per cent of the weight of the skins of potassium or sodium dichromate and 3 per cent of 20° Bé. muriatic acid. The chrome is dissolved in boiling water and added to the water in the wheel, about 65 gallons for 100 lb. of skins. The skins are paddled in the liquor for several hours and left in over night. The next morning they are taken out, struck-out, and dipped in a solution of sodium hyposulphite to which a little muriatic acid has been added. After dipping, the stock is thrown over a horse and allowed to remain for a short time before it is placed in the second bath. This bath consists of 18 lb. of hypo and 5 lb. of muriatic acid in 65 gallons of water for 100 lb. of skins. The hypo is dissolved and added to the water; the acid is then poured in and the stock thrown in as quickly as possible. Some tanners do not add all of the acid at once, two-thirds being added first, and the remainder after the skins have been thrown in. When the yellow color of the stock has turned to light blue throughout the thickest skins the treatment is finished. The skins are taken out, placed over horses for 24 hours, and are then washed and neutralized. Both potassium dichromate and sodium hyposulphite are used in excess, but without injury to the stock, a few pounds more or less for a large pack of skins making no difference in the quality of the leather.

*Process of alum and chrome tanning.*—Skins tanned by the following process work out into a leather which possesses the qualities of both alum and chrome leather. In appearance, plumpness, fine grain, and feel, the leather resembles alum

leather, and chrome leather in softness and durability. The first step consists of tawing the skins in a solution of aluminum sulphate and salt. In the second step the sulphate is fixed on the fibers of the skins by means of a solution of sodium hyposulphite, and after this has been done another solution of sulphate and salt is given to the skins, by means of which they are plumped and the thinness that follows the use of hyposulphite is overcome. By these operations the skins are thoroughly alum-tawed, and, if desired, may be finished without further tanning. To complete the process and produce chrome leather, the skins after the final application of sulphate and salt, are chrome-tanned. In practice the process is as follows:

The skins, after drenching and washing, are drained and weighed. For every 100 lb. a solution is prepared consisting of 3 lb. of aluminum sulphate and 6 lb. of salt in 3 gallons of water, boiled, and allowed to cool. The skins are drummed in this solution for 20 minutes. Then 10 lb. of hyposulphite are dissolved in 3 gallons of water, and this liquor is poured into the machine and the drumming continued for 15 minutes. To finish the first part of the process, a third solution is prepared by dissolving 2 lb. of aluminum sulphate and 3 lb. of salt in 3 gallons of water. This solution is added to the contents of the drum, which is run 30 minutes.

The skins, now plump and full, are next rinsed off in clear water, drained several hours, and then given the chrome liquor, which is used without the addition of water or acid. From 3 to 6 gallons of the concentrated chrome liquor is required for 100 lb. of skins. The chrome liquor is prepared as follows: 5 or 6 lb. of chrome-alum is dissolved in 5 gallons of water without the aid of heat. To this solution is added from 2½ to 3 lb. of sodium sulphate and from 12 to 16 oz. of potassium or sodium acetate, or its chemical equivalent. In a liquor thus prepared, the skins are drummed one hour, or until they are chrome-tanned. They are then allowed to drain 24 hours, washed in the usual manner, shaved and colored. For thick, heavy skins, the quantity of chrome liquor used may

be increased to 6 or 7 gallons for 100 lb. of stock. No free acids whatever are used in this process. Free acid in the solution, added as an element—that is, other than as produced by decomposition of the chemicals—will retard, if not prevent, the reaction necessary to produce leather. For this reason the skins must be perfectly neutral when treatment begins.

After the tanning is completed, the skins should be left in the liquor several hours, then thrown over horses to drain for 24 hours, to allow for complete tannage of the fibers. The leather is then washed in warm borax water, then in clean water, and then shaved, colored, and finished. This process was patented by George W. Adler of Philadelphia, Pennsylvania.

**New two-bath process of chrome tanning.**—This process is similar in manipulation to the regular two-bath process. It can be worked by a two-bath or one-bath method.

The directions for one-bath are as follows: For 100 lb. of skins use 4 lb. of sodium dichromate and 3 lb. of 20° Bé. muriatic acid and sufficient water for the pack of skins to be processed properly. When the skins are thoroughly impregnated with this liquor and seasoned, add to the bath, while the goods are in motion, 20 per cent of the weight of the skins of "S. Z." solution[a] and 35 per cent of "S. K." solution,[b] these two solutions being mixed before they are added to the bath. Then add, the skins being in motion, 5 per cent of 66° Bé. sulphuric acid; but before adding the acid, mix it with about 30 times or more its weight of water. Then add this mixture through a lead-lined wooden funnel, long enough to reach

*a* Use 80 lb. of sodium nitrate and 84 lb. of hot water.

*b* Use 48 lb. of fresh chloride of lime, 48 lb. of soda ash, and 384 lb. of hot water. Dissolve the soda ash in hot water. When all is dissolved, add the chloride of lime through a sieve, keeping the liquor always well stirred. When all the lime is stirred in, let the liquor settle until it becomes clear—say in two days—then draw off the clear liquor for use as above, and throw the sediment away.

Both S. Z. and S. K. liquors may be kept in one vessel—carboy, vat, or hogshead—provided the proportions are maintained, and when wanted, the proper quantity is taken out. A wooden tank or hogshead should be used for making the solution.

In place of S. K. and S. Z. solutions, sodium peroxide and sulphuric acid may be used. To each 100 gallons of water in the vat add 5 lb. and 5 oz. of 62° Bé. sulphuric acid, and stir well; then sift a little at a time 4 lb. of sodium peroxide, while stirring well; use lukewarm water for the bath. When this bath is ready, put the previously chromed skins into it, and paddle them until they are tanned.

to the bottom of the vat, and placed at one corner of it, while the goods are in motion.

The skins are finished after about 1½ days. No damage will result should they remain longer in the liquor. When done, wash and finish them. This tannage produces a finer grain, less contracted, and besides, sulphur as in the hypo process, is not present. Skins treated by this tannage are best for making enamel or patent-finish leather.

*Neutralizing and washing the tanned leather.*—The object of these processes is to remove the acid and salts from the leather and make it perfectly neutral for coloring, fat-liquoring, and finishing. Chrome-tanned leather is unique in one respect: that is, it will stand any amount of washing with water without injury. Water alone, however, removes the acid so slowly that it is common practice for tanners to add a small quantity of alkali to expedite the work.

In all cases of chrome tanning, whether by the two-bath or the one-bath method, the leather should press and drain from 12 to 24 hours to allow the chromium hydroxide to become dehydrated and fixed in the fibers. It is then in the proper condition to be washed and neutralized.

The use of sodium bicarbonate for neutralizing the leather is recommended. It destroys the free acid, helps to fix the chrome, is inexpensive, and does no damage to the leather. An excess of the soda is used in enough water to wash well in a drum. This excess does no harm to the leather. The leather is washed 30 minutes, when the plugs are pulled out and the leather is washed half an hour longer with running water. The skins are then struck out and shaved.

*Neutralizing with borax.*—A common method of removing the acid from the leather involves the use of borax, the quantity required varying with the amount of acid present in the leather: but it should be remembered that only as much should be used as to have the leather still show a very weak acid reaction. As a rule, from 1 to 2 per cent of borax, calculated on the shaver's weight of the leather, is sufficient. The borax is dissolved in hot water and added to the water in which the

leather is washed. The leather is drummed in this water for 40 minutes at a temperature of 80° F. After it has been thus neutralized, it is better to wash it well with running water.

Insufficient neutralization of the leather, which is indicated by blue litmus paper turning red when pressed against the leather in the cut, may cause various difficulties. It may especially cause an unsatisfactory absorption of the fat-liquor, or lead to the dyestuff being fixed too surficially (merely on the surface; little penetration), or precipitated in the bath; besides, leather insufficiently neutralized has a tendency to spew. Some tanners shave their leather before they neutralize it; others neutralize before shaving. In some tanneries the leather is first washed in warm running water. The borax is then dissolved in sufficient water to allow the leather to move freely in the drum, and the treatment in such water, preferably warm, should continue 30 minutes. The leather is then rinsed well in warm water. Where the skins are shaved before they are neutralized and washed, and are fat-liquored or dyed immediately afterwards, the last rinsing should be in water at 125° F., thus raising the temperature of the skins in anticipation of the coloring or fat-liquoring process which follows.

**Notes and suggestions.**—It is not always practicable for the tanner to follow set formulas and rules in chrome tanning, on account of the difference in the raw stock he uses. The skins should be given what they require and no more. In the second or hypo bath it is best to add only about two-thirds of the acid to the hypo solution, then, as the process proceeds, add more acid until the prescribed quantity has been used. The skins should come from the second bath as nearly neutral as possible, and operations should be conducted to attain this result. More chemicals than necessary are generally used, and more than the skins take up. Experience has proved this to be good practice, especially where a paddle-vat is used. The liquors are never fully exhausted when the skins are taken out, yet it is best to run them out and prepare new liquors for the next pack of skins. It is best to let the goods drain over

night from the first bath, and strike them out before putting them into the second bath. When a two-bath process is used, there is no danger of contracted grain, and the leather works out soft and silky and to the greatest possible area of measurement. Skins pickled with aluminum sulphate and salt can be tanned without being de-pickled; but if considered advisable to remove acid pickle, it can be done in a bath of whiting (chalk) and salt, the skins being then washed in warm salt water and tanned; but bicarbonate of soda is to be preferred to whiting, as the latter produces calcium sulphate with slight solubility.

It is feasible in using the two-bath process of chrome tanning to pickle the skins with muriatic acid and salt, and then give them the first bath, which is made of potassium or sodium dichromate and salt without acid. When this is done, the acid pickle serves to liberate the chromic acid in the bath. Whenever pickled skins are being tanned, considerable salt should be added to the first liquor. The first or chrome bath is given most advantageously in a drum; the second or reducing bath may be applied in either a drum or a paddle-vat. There should always be sufficient water used to give proper working conditions. The ratio of potash or soda to the weight of the skins may vary considerably without affecting the result.

Some tanners put the skins into the solution of sodium hyposulphite and then add the acid rather slowly. Others add all the acid to the hypo-bath, and as soon as the liquor turns milky, throw the skins in as rapidly as possible. It is the opinion of the author that the latter method is the better of the two. When the tannage seems to be finished, it is advisable to leave the leather in the liquor several hours or over night, to ensure complete reduction and deposition of the basic chrome salt. The quantity of sodium hyposulphite may range from 10 to 20 lb. for 100 lb. of skins, but it is the general rule to use more than the stock requires, as an excess does no harm, it being rather beneficial to the quality of the leather. It is advisable to dip the chromed skins into a fairly strong solution of hypo before putting them into the second bath. This

dip may consist of 5 lb. of hypo in 10 gallons of water, or a 10 per cent solution of sodium bisulphite. This prevents "bleeding" of the chrome into the second bath, and drawn grain. Sodium hyposulphite is used with acid; in the second liquor, sodium bisulphite without acid.

**Difference between one-bath and two-bath chrome-tanned leathers.**—One of the main causes of the differences between leather tanned by the one-bath method and that tanned by the two-bath method, says the "Shoe and Leather Reporter," is to be found in the fact that free sulphur is deposited on the fibers of the skins by the two-bath when hypo is used for reducing, and not in the one-bath process. In both processes, the chrome salt which actually converts the pelt into leather is a basic one, so that the main difference is not to be sought in the nature of the actual tannage, but rather in some of the side reactions. One of these reactions in the two-bath process, but not in the single-bath, is the liberation of sulphur when sodium hyposulphite and muriatic acid are used in the second bath. It is customary to add the acid to the solution of hypo until a slight turbidity or milkiness appears, before introducing the skins. The sulphur dioxide takes part in the reduction of the chromic acid in the skins, and the free sulphur is precipitated both in the surrounding liquor and in the fibers of the goods. It is the free sulphur that produces the turbidity of the liquor. This sulphur produces softness, gives the leather its white appearance, and acts as a kind of a lubricant to the fibers, so that they slip over one another more readily, producing the effect of softness or mellowness.

Free sulphur can be incorporated into leather tanned by the one-bath process by a special operation proposed by Eitner, the German leather chemist. This operation consists of treating the skins, before tanning, with sodium hyposulphite and acid. The goods are treated first with one, and then with the other, 100 lb. of pelt being drummed for 45 minutes with 100 gallons of water, 20 lb. of salt and 4 lb. of muriatic acid. The goods, after drumming, are allowed to drain, and are again treated for 6 hours with 20 per cent hypo. The same

reaction takes place as that described for the two-bath process, the acid liberating the sulphur from the hypo, but in this case the precipitation of the sulphur takes place entirely in and on the fibers. Skins treated by this process, and then tanned by the one-bath method, have most of the properties of two-tanned leather.

A simple test to prove whether leather has been tanned by the one-bath or the two-bath process, consists in determining whether there is any free sulphur in it. A silver coin is cleaned and moistened, and then wrapped round with a piece of the leather and put in a warm place. In the case of heavy leather a slit should be made with a knife, and the coin placed in it. After an hour or so, if there is free sulphur in the leather, the coin will be found to be darkened or blackened by the action of the sulphur on the silver.

**Chrome-tanned side leather.**—Hides that are intended for chrome upper leather are split out of lime, and the grains are washed, bated, and pickled. The processes of tanning such grains are the same as for the grains of acid-pickled sides. A fine chrome side leather is obtained by tanning the grains in the two-bath process described. The process can be carried out in a paddle-wheel as follows:

The first or chrome bath consists of 6 per cent of the weight of the goods of potassium or sodium dichromate, 5 per cent of salt, and 3 per cent of muriatic acid. The dichromate is dissolved in boiling water and added to the water in the paddle-wheel, about 65 gallons of water being used for 100 lb. of stock. The salt and acid are added and the liquor is ready. The stock is run in the first bath for several hours, then allowed to remain at rest over night. The next morning the grains are removed from the wheel, struck out, and then dipped into a weak solution of sodium hyposulphite to which a little muriatic acid is added. After being dipped, the stock is thrown on a horse, and allowed to remain a short time before it is placed in the second bath of the process.

The second bath consists of 12 per cent of sodium hyposulphite to which 6 per cent of muriatic acid is added, in 65

gallons of water for 100 lb. of stock. When the yellow color has disappeared and the leather is of a greenish-blue color throughout, the tannage is completed and the leather is allowed to drain at least 24 hours, when it is washed and neutralized.

*One-bath chrome process for acid-pickled stock.*—The one-bath process of chrome tanning is generally considered safer and more economical than the two-bath for this class of stock. The tanner can prepare his chrome liquor of chrome-alum and soda, or of sodium dichromate and glucose, or he can buy a concentrated one-bath chrome liquor and use it according to the instructions furnished by the manufacturer.

*Process for alumina-pickled grains.*—Grains that are split from hides pickled with aluminum sulphate and salt may be tanned in the two-bath process the same as acid-pickled stock. They may also be tanned in the manner described for acid-pickled goods with one-bath chrome liquor.

*Process for unsplit sides.*—Sides that are not split previous to tanning are tanned most satisfactorily in one-bath chrome liquor in a vat with paddles. They are bated, washed, and pickled either with acid and salt, or with aluminum sulphate and salt. For every 100 gallons of water in the vat, 35 lb. of salt are put in and dissolved. The hides are then introduced and the paddle run for half an hour. Concentrated chrome liquor is then dissolved in warm water until the solution stands at 50°, Bé. scale. When the hides have been in the salt water 30 minutes, 2 quarts of the chrome liquor are added and the paddle is run an hour. An addition of 3 quarts of the chrome solution is then made to the tan liquor, and the paddle is run 3 hours. More chrome solution is then added, and the hides are kept in the bath until they are tanned throughout.

The tan liquor can also be made by adding 3 gallons of the concentrated chrome solution to the salt water to start with, and then add 3 or 4 gallons more for every 100 gallons of water as the tanning proceeds. When fully tanned, the hides are taken out and pressed for splitting, milled in a dry mill to open them up, jacked and split as desired. The grains and

splits are next put into the drum and re-tanned by being drummed 10 minutes in a solution of salt and then for 2 or 3 hours with 4 quarts of the concentrated one-bath material. The leather is then washed and shaved.

*Neutralizing and washing.*—After being tanned, the leather should be allowed to press and drain 24 hours before it is washed. The first washing is done in a drum with ½ lb. of bicarbonate of soda in 15 gallons of water for 100 lb. of leather. The drum is run a half-hour, when the plugs are pulled out and the leather is then washed another half-hour with running water.

The neutralization can also be accomplished by using 1 lb. of borax in 15 gallons of water; washing in this solution 30 minutes, then washing in running water another 30 minutes, and setting-out and shaving the leather.

**Chrome side glove and mitten leather.**—Hides which are intended for glove and mitten leather should be thoroughly limed and bated in such manner that when tanned they are soft and elastic. The tanning is done most easily with one-bath liquor, the leather after tanning being allowed to drain until the next day. The stock is handled most readily when it is split after liming. Softer leather is made by not washing the leather until after it has been colored, fat-liquored, and dried.

**Chrome-tanned sole leather.**—The following method of manufacturing chrome sole leather is chiefly remarkable for its simplicity. The raw stock is first of all graded, with the object of securing a uniform system of treatment for every hide. In each pack there should be no greater variation of weight than [illegible] lb. This is a very important point, being one of the secrets of the successful production of this class of leather.

*Soaking.*—Five days are allowed for this process when dry hides are used, and one or two days for green hides.

*Liming.*—This is usually accomplished with a sulphide lime mixture, using a 5-day system. The hides from the limes are hauled into a pit of lukewarm water for 24 hours. Coming

from the water pit, the hides are unhaired and fleshed by machine.

*De-liming.*—Before scudding or fine-hairing, the goods are paddled in lukewarm water for 10 minutes, then cleared of loose flesh and fine-haired. After this operation, the weight of the hides is ascertained, and they are again paddled in cold water for a few minutes, then removed and suspended in a pit of cold water until the next morning. Neither acid nor bate is used at this stage, nothing but pure, clean water.

*Pickling.*—On the following day the sides are taken to the pickling-wheel. For every 1200 lb. of hides, take 10 per cent salt and 2 per cent sulphuric acid, and put in just sufficient water to allow the goods to move freely in the paddle-wheel, running the same until by taking a knife and securing a cross-cut from the butt there remains a thin amber line, soft, and almost transparent. To get this effect, a run of one, two, or three hours may be necessary, depending upon the stock and the condition of the pickling solution. On leaving the pickle, the sides are spread out in a smooth pile to avoid creases, and allowed to remain until the next day.

*Tanning.*—The sides are now tacked on sticks and suspended in liquors made of tanolin, chrome or other crystals of equal strength. This process is carried out in 5 or 6 days, the liquor and hides being moved periodically by means of mechanical rockers. The original liquor may be started on a basis of 10 per cent of the chrome crystals dissolved in the volume of water contained in each vat, bringing the liquor up to about 8° Bé. The supplementary liquor for each pack is 2 per cent of salt on the hide weight, added the day the sides are put into the vat. The liquor is plunged up and the sides are suspended in it. On the second day, 6 per cent of tanolin is boiled in quantities of 35 lb., this usually being one pailful, well stirred, and dissolved. It may then be poured into the vat in four portions at intervals of half an hour, the rockers being allowed to run for another hour after the last portion of chrome liquor has been added. The goods should be tanned in 5 days. At the end of the fourth day a crosscut should be obtained, when,

if sufficiently tanned, the hides may receive $\frac{1}{4}$ per cent bicarbonate of soda, dissolved and poured on the surface of the liquor in the vat. If the cutting shows incomplete tannage and unsatisfactory color, the liquor may be made lukewarm by means of a steam pipe boxed inside, the steam being circulated through the vat while the rockers are in motion. When the desired temperature is obtained, the soda may be added, and the liquor agitated one hour. In either case, the addition of soda causes a foam, denoting the acidity of the liquor. It is seldom beneficial to heat the liquor, for although it may hasten the tanning process and help the color, it reduces the substance of the finished product, and is therefore resorted to only in an emergency.

The sides may now be removed from the vat and laid out in a pile, grain exposed to the air, for at least an hour before washing, this being effected in the wheel or drum. A good plentiful supply of clean water is needed at this stage, as it makes all the difference between a poorly and a cleanly finished product. Three or four hours are usually necessary for each wash, when the sides are taken out and spread over a horse to drip for a few hours. After tacking them on frames without stretching, the hides are dried, and then well rolled. For waterproof sole leather, the leather is partly dried and then undergoes a process of fat-liquoring and filling. For this process the method is to dissolve for each 100 lb. of leather—squeezed or semi-dry weight—2 lb. of white soap and 1 lb. of neat's foot oil in 6 gallons of water. This liquor may be used at 125° F., and the leather drummed in it 45 minutes. On removing from the fat-liquor, the sides may be set out on the table or by machine, tacked on frames and dried out. The filling may consist of stearine, paraffin wax, glucose, or other similar substances, mixed in different proportions for various requirements. This filling process improves the impermeability, tightness, and firmness of the leather.

*Other tanning processes.*—There are other methods of pickling and tanning hides, for chrome sole leather. One consists of pickling with aluminum sulphate and salt, and tanning

in vats; and another of pickling with sulphuric acid and salt, tanning in pits or rocker vats.

The hides, after pickling, may also be tanned either in the paddle or mill as given under such leather. In cases of drum tanning, however, the stock should be run for short intervals only, otherwise a drawn grain may result.

Chrome sole leather is also given weight and filling after it is tanned by being drummed with quebracho extract. It is claimed that 7 to 8 lb. of quebracho liquor, 70° bk., for each side of leather should be drummed into the latter after the chrome tanning is completed. Leather treated in this manner resembles vegetable-tanned sole leather in appearance, repels moisture, wears well, and can be sold by the pound the same as the older tannage. This combination process takes about 30 days from the raw hide to the finished product. A combination tannage may also be obtained by suspending the chrome-tanned hides for 10 days in a 40° bk. extract, and then extracting and finishing as for vegetable-tanned stock.

**Chrome-tanned harness leather.**—In the handling of hides for chrome harness leather, the methods of de-hairing and bating should be such as not to deplete them, and preserve the strength of the fibers. To get heavy leather, heavy hides must be used, weighing from 60 to 80 lb. each, and they must be plump, as there is no way of plumping chrome leather.

The hides are trimmed and hung in cold water to soak. After soaking 24 hours, they are split into sides, put back into the water, and soaked 24 hours longer; when they are fleshed and soaked over night in fresh water. Splitting into sides and fleshing may be done after the hides have soaked 48 hours; they are then re-soaked over night to be made as soft and clean as possible.

*Liming.*—The sides are next toggled together in a long chain and put into the first lime. For this class of stock a fairly long liming is necessary, and a small amount of sodium sulphide at the start is desirable also. When the hides come from the limes, they are passed into clean warm water, from which, after 3 or 4 hours, they are unhaired on a machine. After

the hair has been removed, the hides should be washed with running water for 15 minutes, then put into clean warm water for 2 hours, after which they are fine-haired and worked on the grain. Thorough working-out of the grain is necessary to ensure clear, tough grain which will not crack.

*Bating.*—This may be done with lactic acid or with any other suitable bate; the bacterial bates, of course, produce a finer-grained leather than any acid de-liming process.

*Pickling.*—A paddle-vat is used for this process. To each 100 gallons of water in the vat, 30 lb. of salt are added, and to this liquor, for each 100 lb. of hides, 2 lb. of sulphuric acid and 15 lb. of salt. For succeeding packs, 15 lb. of salt and $1\frac{1}{2}$ lb. of acid are used.

The paddle should be run for an hour, and then allowed to rest 2 hours, then run half an hour, and the hides left in the liquor over night. The next morning they are removed and placed in piles for 24 hours; they are then put into the tan liquor.

*Tanning.*—A good way to tan the hides to get full flanks and bellies, and a fine, smooth grain, is by the use of rocker-vats, although paddles and even drums may also be employed. The same method of chrome tanning may be used as described under any of the one-bath processes.

When fully tanned, the leather is put down in smooth piles for 48 hours. It is next washed for half an hour in water to which 1 lb. of borax has been added for each 100 lb. of leather, and then for one hour in cold running water.

Another practical mode of tanning consists of pickling the hides with aluminum sulphate and salt, then drying, dampening, and softening with warm water, and finally tanning in chrome liquor. This process produces well-tanned leather.

*Re-tanning.*—After being tanned and washed, the leather is re-tanned with quebracho extract or with gambier, preferably the former. For each average side, from 1 to 2 lb. of solid quebracho extract is used. It is dissolved in boiling water, enough water being then added to make 15 gallons of liquor

for each 100 lb. of leather. The sides are run in the liquor one hour, then placed in piles until the next day, when they are either pressed or put through a wringer. If pressed, they should be run in a dry mill for 15 minutes to remove the press marks. The leather is then shaved just enough to remove the flesh and make the backs smooth and clean. When gambier is used, the quantity is about 4 lb. for 100 lb. of leather; otherwise the process is the same as with quebracho.

**Chrome-tanned belt and strap leathers.**—Hides for these two classes of leather are treated in the beam-house in the same manner as those for chrome harness and sole leathers. For belting leather, however, they are trimmed into butts after liming or after bating. The butts should each be about 4½ feet long and 4 feet wide, though some may have a width of 4½ feet. The bellies and heads are tanned with extract and are sold as offal. The butts are then tanned with chrome liquor in a drum or in a vat. Tanning in a drum is effected by pickling the butts and tanning them with one-bath chrome, according to the procedure outlined for chrome upper leather. When a vat is used, the process is the same as for harness and sole leathers.

After having been tanned and washed, the butts are fat-liquored with soap, oil, and degras—1 lb. of soap, 5 lb. of degras, and 2 lb. of neat's foot oil boiled an hour in water, to which 6 oz. of borax have been added, being sufficient for 100 lb. of leather. There should be 12 gallons of fat-liquor. The butts are first run in a drum, together with 12 gallons of water at 160° F., and 4 oz. of salts of tartar (potassium carbonate) for each 100 lb. of leather. The water is drained off and after the fat-liquor, at 140° F., has been put in, the leather is run in it 45 minutes. It is then placed in piles for 24 hours, when it is taken and set out good and hard. The grain is oiled with cod oil, and the butts are then hung up to dry. The next operation is stretching, the object of this being to get all the stretch out of the leather. The butts are soaked in hot water and piled down over night. The next day they are stretched in belt stretchers as tight as possible

and allowed to get thoroughly dry; they are then finished and ready for cutting up into belts.

Good leather is also made by fat-liquoring the butts with a solution of soap, drying and dampening them, and then stuffing them with degras, paraffin, and paraffin oil. Drying and stretching is effected in the manner that has been described. A satisfactory stuffing mixture is made of 4 lb. of cod oil, 2 lb. of black degras, and 6 lb. of stearine for 100 lb. of leather. No soap is used with this stuffing, which is applied at 165° F. The butts are then dried and finished.

The trimmings taken from chrome belts may be re-tanned with hemlock or oak liquor and sold as trimmings from oak belts. They are first drummed in hot salt solution, next given a light re-tan with hemlock extract, and then laid away in strong hemlock or oak liquor, preferably the latter, until they are colored throughout, when they are dried and sold.

*Strap leather.*—There are numerous uses for which soft strap leather is suitable. The beam-house treatment and the tanning are the same as for chrome harness leather. When tanned, the leather is washed, shaved, and fat-liquored with 4 lb. of moellen degras, 2 lb. of cod oil, 2 lb. of wool grease, 1 lb. of soap, and 7 oz. of alkali, boiled, and made into an emulsion with 12 gallons of water for 100 lb. of leather.

After the leather has been drummed in this fat-liquor 40 minutes, the liquor is drained off, and the leather washed in warm water containing 1 pint of ammonia in 10 gallons of water. This water is drained off at the end of 10 minutes, and the leather is then re-tanned with gambier, 4 lb. dissolved in 15 gallons of water being used for 100 lb. of stock. The leather is drummed with this liquor for an hour; it is then set out on the grain and hung up to dry. Any rough spots can be buffed off before the leather is finished.

The finish is made by boiling 8 oz. of Irish moss, 8 oz. of starch, 8 oz. of soap, and 1 pint of olive oil in 4 gallons of water for 30 minutes. When cool, the solution is strained and enough water is added to make 8 gallons of finish. The leather is given a coat of this finish, staked on the flesh side,

rolled, and hung up to dry or tacked in frames. It should be rolled immediately after staking and before it is dried. When dry, it is given a second coat of finish, dried, and rolled again. This process makes tough, pliable, and durable leather which outwears the best bark-tanned product.

**White side leather.**—A white leather which closely resembles alum leather is made by tanning the grains of split hides in a one-bath chrome process, and then either bleaching the leather with borax and sulphuric acid, or treating it with flour, or both. The hides should be split out of lime; the grains are then bated and pickled with sulphuric acid and salt. When the leather is tanned, wash it in a fairly hot 2 per cent solution of borax for a half-hour. Then prepare a solution of sulphuric acid and water, made by adding acid to water until the solution is 1 per cent in strength. Take the leather from the borax bath and wash it in a drum in the acid bath; then wash it in clear water to remove the acid; next fat-liquor it.

*Treatment with flour.*—Drumming the leather with flour is another way to make it white. The flour treatment can be used alone, or after the borax and acid process. The leather is washed after tanning, and is then given the flour treatment, 50 lb. of flour being sufficient for 50 to 100 sides, according to size. The flour should be stirred into a thin paste with water before it is used. The leather is drummed with the flour for 2 hours, and is then fat-liquored.

Acid fat-liquor dissolved in hot water is most suitable for this leather, from 4 to 6 lb. of the soluble oil being sufficient for 100 lb. of chrome leather. It is mixed with 10 gallons of hot water and applied to the leather immediately after the flour treatment. The leather is then dried, staked, and finished.

*Finishing.*—After having been staked, the leather is run in a closed drum, together with powdered chalk or soapstone, for an hour or longer; it is staked again, and then is ready for use. Properly tanned and fat-liquored, the leather finishes up soft and white, and is excellent material.

*Tanning with aluminum sulphate.*—White leather which is suitable for various purposes is made by tanning acid-pickled

grains and flesh splits with a solution of basic aluminum sulphate. Splitting is done preferably out of lime, the stock then being bated and pickled.

To prepare the tan liquor, boil 12 lb. of sulphate in 10 gallons of water; also dissolve 24 oz. of bicarbonate of soda in 1 gallon of hot water. Pour the soda solution slowly and with constant stirring into the sulphate solution. When mixed, let the liquor cool to 80° F. before using.

Put the pickled stock into a drum, together with 10 gallons of water, 1 lb. of Glauber's salt and 3 lb. of common salt for 100 lb. of stock. Drum 20 minutes, then drain off the liquor. Put 10 gallons of lukewarm water and 4 lb. of salt into the drum, and run the sides in this brine for 10 minutes. Then pour half of the sulphate and soda liquor into the drum and run the sides in it for 3 hours. At the end of that period take the stock out and place it over a horse to drain until the next day, then hang it up to dry. When dry, put the leather back into the drum, together with a few pails of water, and run 10 minutes. Then add the other half of the sulphate-soda liquor and drum 3 hours. Now add sufficient one-bath chrome liquor to give 2 per cent of dichrome on the weight of the stock, and mill one hour. Horse-up the leather until the next day, and then hang it up to dry.

*Fat-liquoring with acid fat-liquor.*—When dry, let the leather remain in the dry condition in a clean dry room for two weeks; then dampen it with warm water preparatory to fat-liquoring. Sulphonated oil imparts the necessary softness to the leather without discoloring or making it greasy. For each 100 lb. of dry leather use 7 lb. of the oil dissolved in 10 gallons of water at 95° F. Drum the moistened leather 40 minutes with the solution of oil; then let it drain over night. The next day strike out the grain and apply a mixture of talc, 2 parts of glycerine, and 4 parts of water; then hang the leather up to dry.

*Finishing.*—This consists simply of moistening and staking the leather and tacking it on boards. When dry and taken from the boards, if not soft enough, re-stake it; or if stak-

ing does not soften it sufficiently, give it more fat-liquor; and if the leather does not appear to be entirely tanned it can be returned to the drum and re-tanned with sulphate and soda liquor, and then dried as before. The grain may be buffed off if desired; and the appearance of the flesh side can be improved by buffing on an emery wheel.

If it is desired to re-tan the leather into chrome stock, this can be done by wetting the goods back and re-tanning with one-bath chrome liquor, coloring, and finishing the same as regular chrome leather.

**Chrome velvet leather.**—The chrome-tanned sides are fat-liquored in the usual manner, some substance being added, which, during the subsequent dyeing, isolates the fibers of the leather in such manner as to allow its being soaked and softened without difficulty; dextrine, grape sugar, syrup, etc., are used for this purpose. The leather is then dried and buffed. In case of grain leather, either the flesh side is buffed or the grain is snuffed. Flesh splits are buffed on the flesh side. The snuffed leather is then drummed with warm water until it has regained its original softness, and is dyed with acid dyestuffs and sodium bisulphate. During or after the dyeing, a somewhat larger quantity of gambier or sumac is added than is otherwise customary with chrome leather, in order to impart the necessary firmness to the leather. The velvet is then raised by working the leather in the dry drum after it has absorbed some moisture by treatment with wet sawdust.

**Chrome-tanned patent leather.**—Hides intended for chrome patent leather should be carefully selected after they have been de-haired. The grain must be as nearly perfect as possible. Only small pattern and plump hides can be made into patent leather, as large, spready, and thin hides are of loose texture when tanned. After the hair and fine hair have been removed, the hides should be washed in a wash-wheel. They are then bated, which must be carefully done, because if the hides are bated too much the leather is loose and breaks coarse, and if not bated enough, the grain is harsh and tender. A thin grain is to be preferred to a thick one. The former

has more elasticity than the latter, and is therefore less likely to crack. After the hides are bated they should be washed a few minutes in warm water to cleanse the grain. Pickling then follows.

The one-bath process of tanning is to be preferred for patent leather, as it gives the most measurement and there is no sulphur to cause trouble after the leather is finished. Drum the grains in salt water; then give them the tanning liquor and continue drumming until the leather is fully tanned. The leather can be washed, colored, and fat-liquored in the same manner as other chrome leather.

*Coloring and fat-liquoring.*—Coloring is best effected with logwood (hæmatin) and direct chrome leather black. Fat-liquoring is done most satisfactorily with degras and soap, or with the former alone. It is then struck out, oiled on the grain, and hung up to dry in a warm room. Drying should proceed rapidly so that the leather will dry as firm as possible. Ordinarily, chrome patent leather requires de-greasing before finishing.

*Staking and finishing.*—When the leather has dried, it is dampened, staked, and tacked out as tight as possible. When taken from the frames, it is usually sufficiently firm to be finished, were it not for the grease in it, which must be removed. Some of the grease applied in fat-liquoring, and some of the oil applied to the grain, does not combine with the fibers, and unless removed, causes the varnish to slip over the leather, making finishing impossible. De-greasing is done most satisfactorily with naphtha. Where a large quantity of leather is being made, a naphtha plant is necessary or else the leather must be sent to a de-greasing establishment, and treated by those who make a business of extracting grease from leather. De-greasing can also be done by soaking the leather in naphtha for 10 hours, then pressing out the naphtha and drying the leather. The action of the naphtha upon chrome leather is harmless; and where the leather has been well fat-liquored and oiled, no strength is lost through the de-greasing operation.

Sides for patent leather can be tanned with chrome liquor and then split to the desired substance and re-tanned. This improves the "break" of the grain and softness to feel. Sodium sulphide should be used with lime in preparing the hides for tanning. It gives the grain an appearance similar to coltskin, removes the fine hair, and produces fuller and plumper leather than lime alone or lime and red arsenic. All fine hair must be removed, as it is one of the worst troubles to contend with in making patent leather. Hides that weigh more than forty pounds each are not suitable for patent leather.

**White chrome.**—On wet pickled weight, run the stock in a mill with 2½ per cent formaldehyde, 7½ per cent aluminum sulphate, 10 per cent salt, and 12 gallons of water. Add this in four portions at half-hour intervals, and run for 3½ hours. Horse-up over night. Return the stock to the drum, and add enough one-bath chrome liquor to give 2 per cent sodium dichromate on the weight of the stock. Run for an hour and add ½ per cent of sodium bicarbonate. Horse-up over night. Then neutralize and wash, and fat-liquor with 1 per cent glycerine, 5 per cent egg-yolk, and 10 per cent of flour. Dry and re-fat with sulphonated oil, and finally dry, sammie, stake, and tack.

**Tanolin T.**—Calfskins and coltskins may be tanned with "tanolin T" in a paddle-wheel, in the manner outlined below:

*Pickling.*—Weigh the skins after washing from the bate.

*First pack.*—For each 100 gallons of water in the tub dissolve 40 lb. of salt. Then for each 100 lb. of skins add 1½ lb. of 66° Bé. sulphuric acid.

Start the paddle, throw in the skins and allow the paddle to turn 3 hours. Then shut down the paddle and allow the skins to lie in the liquor until an hour before stopping for the night; then run an hour, then allow the skins to lie in the liquor over night. The next morning run the paddle one hour and then haul the skins, and either horse up, smooth or pile down flat for 24 to 48 hours. When hauling the skins from the tub, arrange it so that the surplus liquor clinging

to them may drain back into the tub before horsing-up or piling-down.

*Second pack.*—Strengthen the liquor by adding 10 lb. of salt and $1\frac{1}{2}$ lb. of sulphuric acid for each 100 lb. of skins. Then proceed in the same manner as for first pack.

*Third, fourth, fifth and sixth packs.*—Strengthen the liquor by adding 8 lb. of salt and $1\frac{1}{4}$ lb. of sulphuric acid for each 100 lb. of skins, and proceed as for previous packs.

*Seventh, eighth, ninth, tenth, eleventh and twelfth packs.*—Strengthen the liquor by adding 6 lb. of salt and 1 lb. of sulphuric acid for each 100 lb. of skins, and proceed as for previous packs.

After 12 packs have been pickled, clean out the tub and start again.

This formula requires that each pack must contain enough skins to make a full load for the size of the paddle-tub used. If less than a full pack is to be pickled, a drum should be used.

*Tanning: First pack.*—For each 100 gallons of water in the paddle dissolve 50 lb. of salt. Then for each 100 lb. of skins to be tanned, dissolve 9 lb. of tanolin T, as directed below.

Warm the liquor to 75 or 80° F. Start the paddle and throw in the pickled skins (never throw in the skins unless the paddle is running).

Take half of the tanolin solution and add to the contents of the paddle and run for an hour; then add the other half and run the paddle for the remainder of the day. Two hours before stopping for the night, warm the liquor to 85 or 90° F. and add $\frac{1}{2}$ lb. of bicarbonate of soda or borax, dissolved in a little water, for each 100 lb. of skins. Leave the skins in the liquor over night. On the second day run the paddle 2 hours in the morning and 2 hours in the afternoon; warm up the liquor again before stopping for the night, and again leave in the liquor over night. When the skins have been in the liquor 48 hours they should be tanned, but if any doubt exists run the skins until they are tanned. When completely

tanned they are removed and horsed-up smooth or piled down flat, and allowed to drain 24 to 48 hours.

Never start tanning in the paddle-tub unless there is sufficient time before closing for the day to run the paddle at least 2 hours after the last portion of the tanolin solution has been added. If the skins are completely tanned a piece cut off from the thickest part should stand boiling. If this shrinks materially, and becomes hard after boiling, the skins are not thoroughly tanned, and should be left in the tan liquor and run until the leather will stand boiling. Be sure that the skins are completely tanned. There is no danger of over-tanning the skins by leaving them too long in the tanolin.

*Second pack*:—Strengthen the liquor by adding 8 lb. of salt and 9 lb. of tanolin T for each 100 lb. of skins, as directed for the first pack.

*Third, fourth, fifth, sixth and seventh packs*:—Strengthen the liquor by adding 6 lb. of salt and 7 lb. of tanolin T, for each 100 lb. of skins, as directed for the first pack.

*Eighth, ninth and tenth packs*:—Strengthen the liquor by adding 4 lb. of salt and 6 lb. of tanolin T for each 100 lb. of skins, as directed for the first pack.

Two hours before stopping for the night of the first day, for each pack add to the liquor ½ lb. of bicarbonate of soda, dissolved in a little water, for each 100 lb. of skins.

After 10 packs have been tanned, clean out the tub and start again.

*Dissolving tanolin T*.—Dissolve this substance in boiling water, using 1 gallon of water for every 3 lb. of tanolin. The best way to effect its solution is to put the proper amount of water into a barrel or tank, insert a steam pipe, and bring the water to the boiling point. Then add the tanolin to the water, stirring it constantly with a stick to ensure its being well wetted, and boil vigorously until it is completely dissolved. This will take about 10 minutes. Allow the solution to stand until the temperature is reduced to 100° F. Do not put the tanolin in water and then let it stand before boiling and dissolving.

*Neutralizing and washing.*—After draining 24 to 48 hours from the tan liquor, the skins are thrown into a drum with a solution made of 2 lb. of bicarbonate of soda or borax, in 10 gallons of water for each 100 lb. of skins. Mill in this solution for 45 minutes. Then wash the leather in running water until neutral to the taste. The leather must be washed long enough to remove all acid and salt.

**To increase suppleness.**—When heavy chrome leather is required to be soft and supple, and yet must not contain much grease, as, for example, for automobile tire leathers, the method recommended by Eitner is satisfactory. In the ordinary method of chrome tanning by the two-bath process sulphur is deposited in both the liquor and the fibers of the leather, and when thus deposited in the fibers, it produces softness and suppleness.

A method for increasing the amount of sulphur deposited in the fibers is as follows: In the first bath, for every 100 lb. of pelt, take 3 lb. of chrome-alum, 1 lb. of sodium bichromate, and 2 lb. of hydrochloric acid. In the second bath only sodium hyposulphite is used to the extent of 8 lb. No acid is added, as there is sufficient in the goods to produce the desired effect. By this means the sulphur is deposited on the fibers, the result being a soft, supple leather. It has a green color, but if it is desired to make it whiter, the following treatment may be applied: The goods are first pickled for 1 or 2 hours with 1 gallon for each pound of pelt in a solution containing 20 per cent of salt and 5 per cent of sulphuric acid, and 4 per cent of sodium bichromate is then added. This constitutes the first bath; the second bath contains hypo only.

Ordinary one-bath leather can be made to represent two-bath leather by incorporating sulphur in the fibers. Before the goods are tanned, they are treated alternately with hypo and hydrochloric acid, then tanned by the ordinary one-bath process. This method produces a chrome leather with a large amount of free sulphur, which makes it very supple. The process can be carried out in either order, or even repeated

more than once, that is, either hypo first, followed by hydrochloric acid and salt or the reverse.

**Dissolving chrome-alum.**—Several substances which are used in the tannery have the peculiarity that while being fairly soluble in water, they dissolve very slowly. For example, chrome-alum is soluble to the extent of 1 part in 7 or 8 parts of water, but it dissolves very slowly. If this salt is used and some remains undissolved there is danger of stains or uneven results being produced by the contact of the solid particles with the skins. In this case it is better to make up the solution some time in advance to be sure that all the crystals are dissolved. When this is impossible, or where the solution is required immediately, it is better to adopt some other means than merely stirring the crystals on the bottom of the vessel. A better way is to suspend the chrome-alum in a basket, coarse bag, or some sort of strainer in the water, so that the crystals are in contact with the water at the top of the vessel. By this means the alum is much more quickly dissolved, because, as it dissolves, the solution falls away from it by gravity, thus exposing a fresh portion of the crystals. If the solution of chrome-alum is to be used in the drum, then, of course, it may be dissolved in the requisite quantity of water by agitation in the machine. With some substances that dissolve slowly it is possible to hasten the solution by using hot or boiling water; but in the case of chrome-alum, the solution thus obtained is different from that in cold water, the latter being of a violet color, while that in hot water is green.

The two solutions differ chemically to the extent to which the chrome-alum is hydrolized, and theoretically, one would expect the violet-colored solution to produce better tanning results than the green one, but the tanning effects are generally the same in both cases. In experimental cases, two similar packs of calfskins were tanned in the two different colored solutions (made basic with soda), and after being tanned, were neutralized, fat-liquored, dyed, and finished, but with no apparent difference in the result. It was therefore con-

cluded that it is not worth the time and trouble to make the violet-colored solution.

**Aluminum bisulphite reduction.**—The modifications of the ordinary chrome processes of tanning are almost legion, particularly so in connection with the production of one-bath chrome liquors. For the production of the latter, there are two general types of method, the first involving the use of a chromium compound, such as chrome-alum, which is rendered basic by the addition of some alkali, such as soda. The modifications in this branch include the use of different alkalies for rendering the salt basic, and also the use of different classes of chromium compounds. The most common, of course, is chrome-alum, of which the active constituent is chromium sulphate. Other chromium salts which have been advocated are chromium formate, chromium acetate, and chromium chloride.

In the second type of method for the production of one-bath chrome liquors, potassium or sodium bichromate is taken, and reduced by some reducing material. The chief modification in this type of process rests in the agent which is used for the reduction, both organic and inorganic materials having been employed. Of the organic materials, probably the most common and the most widely used have been cane sugar, glucose, glycerine, and alcohol; while the inorganic materials include sodium bisulphite and sodium hyposulphite.

According to a German patent taken out by M. F. Hirch, the reduction is carried out by means of a solution of aluminum bisulphite, which, it is claimed, has the following advantages over hypo or sodium bisulphite:

There is no deposition of free sulphur as with sodium hyposulphite, and no great evolution of heat as with sodium bisulphite. The deposition of aluminum hydrate is formed in the skin. The reduction should be carried out without the addition of acid. If a solution of aluminum bisulphite of about 14° Bé. be added to a 2 per cent solution of chromic acid, the complete reduction of the chromic acid is attained without any precipitation. If, on the other hand, a solution of

one-third the above concentration be used, the reduction of the chromic acid is complete, but at the same time a precipitation is produced in the liquor.

The first treatment, that is, with the concentrated solution of bisulphite, is suitable for tannage in one bath, while the liquor produced by the use of the weaker bisulphite solution is suitable only for the tannage in two baths. The following is given as a practical example: The skins, de-haired, delimed, and pickled as usual, are submitted to the following treatment: The bath consists of 5 per cent of sodium bichromate, 2½ per cent of hydrochloric acid, and 180 per cent of water, calculated on the weight of pelt. The goods are allowed to turn in this liquor for 3 or 4 hours, and are then placed in a pile for 12 hours. Finally they are transferred to the second or reducing bath.

This bath consists of 36 parts of solution of aluminum bisulphite at 14° Bé., and 220 parts of water for each 100 parts of pelt. The goods are turned in this liquor for 4 hours, when the tannage should be complete, with the grain even and smooth. The leathers tanned by this method are more resistant than those produced by other processes, and can be dyed more easily and more regularly, partly because the deposition of sulphur is avoided and partly because the alumina forms a mordant which is very favorable to dyeing.

**Recovery of chrome residues.**—In the two-bath method of chrome tanning, the first bath, which consists of an acidified solution of potassium or sodium bichromate, is never fully exhausted. It has frequently been proposed to utilize the residual chrome in this bath by making use of a standing bath, that is, never wholly discarding a bath, but adding each time a quantity of bichromate and acid sufficient to restore its original strength. Unfortunately, this renewal of the bath is an extremely complicated matter.

It is probably more practical with our present knowledge not to try to utilize this chrome again in tanning, and by so doing produce a poorer quality of leather, but to recover the chrome in some form suitable for some other purpose.

Two processes have been proposed for the recovery of chrome as a by-product, both of which can be worked profitably, provided proper care is taken and operations are on a sufficiently large scale to warrant the expenditure for labor.

The first process consists of the precipitation of the chrome as chromate of lead or chrome yellow. There is an extensive demand for this pigment, and the particular shade is not of great importance so long as it is strictly uniform. In order to obtain uniformity, the precipitation should be always made under as near the same conditions as possible and to obtain brilliancy, the solution should be filtered before precipitation takes place, and some alum added as a clarifying agent. White sugar of lead (lead acetate) should be used for precipitation, and a filter-press is essential for collecting the precipitate. The product may be dried or sold in pulp form to manufacturers of mixed paint. The price obtained for the chrome yellow depends upon the care with which it is made, but with ordinary precaution, this working-up of a by-product is fairly remunerative.

The second method of utilizing the waste chrome is to reduce it with sodium bisulphite or sulphurous acid gas, precipitate with soda ash, collect the chrome hydrate so formed in a filter-press, wash it thoroughly, and use it in the manufacture of one-bath tan liquors. This method is in many ways preferable to the manufacture of chrome yellow, as it does not involve the worry of looking for an outside market. Even in the profitable recovery of this chrome, the liquors must be analyzed, and no great excess of reducing agents or soda should be employed, otherwise these chemicals may be wasted and no real gain obtained.

**Chrome-tanned buckskin.**—The skins after the final washing are pickled either with sulphuric acid and salt, or with aluminum sulphate and salt. The goods are then allowed to drain until the next day, when they are tanned in a one or a two-bath process. Excellent chrome buckskin is obtained by tanning the pickled skins in a two-bath process,

and good leather may also be made with any of the one-bath processes.

*White chrome buckskin.*—An excellent white buckskin is made by tanning with one-bath chrome liquor and then treating the skins with flour.

**One-bath chrome tannages.**—While a great many prescriptions have been published for one-bath chrome tannages, preparation of a proper one for any given purpose is still considered a valuable trade secret. A little consideration of the one-bath chrome tan liquor from the chemical point of view should therefore be of some interest.

Of first importance is the source of the chromium. Sodium dichromate is almost universally the cheapest raw material. The exception is chrome hydrate, it being occasionally possible to obtain chromium in the form of hydrate relatively cheaper than in the sodium dichromate. This is so because in some chemical operations the dichromate is used simply for its oxidizing effect, and when the chromium is reduced, its work is done; then it is precipitated with sodium carbonate, washed and offered for sale as a by-product. Only a limited supply, however, can be obtained from this source in the United States; but large quantities are secured from European coal-tar dye-works. The dichromate contains almost exactly 50 per cent of chromic oxide, and 100 per cent chromic oxide in this form therefore costs just double the price of the dichromate. As in the dichromate, the chromium is present in the form of chromic anhydrite and as it must be in the reduced or chromic oxide form, for use in one-bath liquors, there has to be added to the cost of the dichromate that of the acid required to set free the chromic anhydrite, as well as that of the reducing agent used to get it into the chromic oxide form. For example, the cost of a liquor containing 100 lb. of chromic oxide made by reducing sodium dichromate with glucose, may be figured as follows:

| | |
|---|---|
| 200 lb. sodium dichromate at 7 cents per lb.......... | $14.00 |
| 280 lb. sulphuric acid at $1.10 per 100 lb............ | 2.98 |
| 50 lb. glucose at 3 cents per lb...................... | 1.50 |
| Total cost of chromic oxide.......................... | $18.48 |

Sodium bisulphite may be used as the reducing agent in place of the glucose, in which case the cost shows as follows:

| | |
|---|---|
| 200 lb. sodium dichromate at 7 cents per lb.......... | $14.00 |
| 163 lb. sulphuric acid at $1.10 per 100 lb........... | 1.80 |
| 600 lb. bisulphite at 85 cents per 100 lb............ | 5.10 |
| Total cost of 100 lb. of chromic oxide............ | $20.90 |

These liquors, as calculated, include the cost of the acid which is required to hold the chromic oxide in solution. If chromium hydrate is used, the cost of this acid must be figured; for example, the chromium hydrate is usually sold in the form of a 20 per cent paste, and the cost of a liquor containing 100 lb. chromic oxide is:

| | |
|---|---|
| 500 lb. chromium hydrate at 3½ cents per lb........ | $17.50 |
| 210 lb. sulphuric acid at $1.10 per 100 lb.............. | 2.31 |
| Total cost of 100 lb. of chromic oxide............... | $19.81 |

The cost of a liquor made of chrome-alum to contain 100 lb. of chromic oxide is readily calculated, as this salt contains almost exactly 15 per cent of chromic oxide; therefore, it requires 667 lb. of chrome-alum at 5 cents a pound to supply 100 lb. of chromic oxide, or a total of $33.35.

The cost price of the materials is based on normal market conditions, and as the market fluctuates, new values can be readily substituted in the calculation given.

**Theory of chrome tanning.**—The next step in this treatment is to modify the liquor so that it will produce good leather. This is a matter of so much importance and so little understood, that a great many tanners find it good business policy rather to pay an extra price for a liquor already prepared, and which has been accurately adjusted to conditions they desire, than to attempt to make a liquor of their own. In general, this desired modification of a tanning liquor is described by the rather vague term of "basicity." To understand properly what is meant by this, we must consider the theory of the one-bath chrome tannage a little, that is, as much as it is known of it: According to present knowledge, salts of all descriptions, when in solution, dissociate, that is,

break up into acid and basic radicals or ions, and the chemical properties of these ions constitute the properties of the solution. In the case of salts of strong acids and strong bases, such as sodium sulphate or sodium chloride, the strong basic or positive character of one ion is in effect neutralized by the strong acid or negative power of its opposite ion, and a neutral solution results in a solution of such a salt. On the other hand, with a salt of a strong base and a weak acid, as sodium carbonate in solution, there is a condition in which the strong positive character of the sodium ion far overbalances the weak acid character of the carbonic ion, and the solution has marked basic or alkaline properties. While in the salts of weak bases and strong acids—such as aluminum and chromium sulphates—the acidic or negative character prevails, and solutions of these act in many ways as if they contained free acid. In fact, the solutions may to a certain extent be said to contain also free acid by the taking-on of water—the phenomenon known as hydrolysis—which is connected with the facts of dissociation already cited, in the equilibrium, as it is called, of the solution. With these theories in mind, we can perhaps consider and explain better some of the observations on the behavior of the chrome tan liquor. An untanned hide or skin is strongly swollen or plumped by both acids and alkalies. The reason for this phenomenon has never been adequately demonstrated. Perhaps as good a theory as any other is that both the acid and alkali combine chemically with the hide fiber in such a way as to reduce its permeability, and thus the fibers become swollen by solution-pressure. Neutral salts deplete, reduce, or prevent any swelling of the hide. This action also has not been thoroughly explained, but it, too, is doubtless connected with the increase of osmotic or solution-pressure.

If a chrome tanning liquor is made up of chromium sulphate and nothing else in solution, it will, from the considerations above, be seen to possess strongly acid properties. A skin immersed in such liquor will be excessively plumped; the tanning, however, will proceed very slowly, because as

treatment constitutes, the deposition of the chromic oxide will continually augment the acid character of the liquor, and by so doing the tendency of the chromic oxide to deposit will be retarded, until finally a condition is reached when no oxide at all is deposited, that is, the liquor will cease to tan. If to the liquor containing only chromium sulphate, common salt, (sodium chloride) be added, ionization will be prevented, the percentage of acid, however, will not be reduced, but the plumping effects will be obviated. Such a liquor will tan with the same degree of slowness as a pure solution of chromium sulphate, a better leather being, however, produced, because the excessive plumpness is prevented. If, in addition to the common salt, sodium carbonate be added to the liquor to neutralize the acid formed by the hydrolysis of the chromium sulphate, the third factor necessary to complete the tan liquor will be present.

By combination with the acid, the sodium carbonate forms sodium sulphate, and this being a neutral salt, will assist the common salt in keeping down the plumpness, at the same time tending to form a basic chromium sulphate. The amount of sodium carbonate that can be added, is, of course, strictly limited, because an excess will cause the precipitation of chromium hydroxide; and even before this point is reached, so much of the acid may be neutralized that the solution will be unstable and practically decomposed by the skin. A solution in this condition will be found to plump as much as a strongly acid solution. It should perhaps be noted here that there is a difference between the rapidity with which solutions penetrate and the speed with which they tan. The acid solutions penetrate more rapidly than neutral solutions, but do not tan so fast; thus a skin struck through in a too acid solution will be found to be under-tanned. In practice, only the tan liquor made by the solution of the chrome hydrate in sulphuric acid will be found simple enough to modify as above described.

The liquor made by reducing the dichromate with glucose will contain considerable sodium sulphate and some salts

of organic acid, obtained from the incomplete oxidation of the glucose. The influence of these latter, is, however, almost negligible in regard to diminishing the plumping effect, but they do retard the tanning. As the amount of such salts varies according to the temperature at which the dichromate has been reduced, they constitute an objection to the tan liquor made by reduction with glucose, as they make its action slightly uncertain. The liquor made by the reduction with bisulphite is therefore slightly superior in its regularity, although a little more expensive.

The concentration of the liquor also exerts a pronounced influence upon its tanning properties. In the first place, all the constituents of a liquor should be proportioned to each other, and for sure results their ratio should not be changed. It should be remembered that the neutral salts are a constant factor, while, on account of the chromic oxide being taken up by the skin, the amount of this and of the acid present is variable, the one constantly decreasing and the other constantly increasing.

Finally, of utmost importance is the condition of the skins when they are put into the tan liquor. They may be acid or neutral, plump or depleted, but their condition should always be the same, or allowance made for it in the tan liquor.

**Calfskin glove and mitten leathers.**—Glove leather of durable quality is made by tanning calfskins with chrome. The most suitable are those which are large and thin. During the processes of liming, bating, and pickling prior to tanning, the skins are handled in the same manner as those for shoe leather, except that it is advisable to lime them somewhat more thoroughly, so that the leather will be soft and durable.

Tanning is done by the two-bath or one-bath process in the manner that has been already described. Another excellent way to tan the goods is first to give an alum tannage, dry them out, and then re-tan with one-bath chrome liquor.

**Chrome lace leather.**—Hides for lace leather are limed and bated in about the same manner as those for upper stock. A fine grain is not essential. Sodium sulphide is used in the

lime to hasten the de-hairing and give toughness to the hides. De-liming can be done satisfactorily with lactic acid. The hides are next pickled with sulphuric acid and salt, and are then tanned.

Chrome lace leather is made by tanning the pickled sides with one-bath chrome tanning material the same as chrome upper leather, and then fat-liquoring and finishing in the following manner: The tanned and neutralized leather is split. The flesh splits can be finished into gusset splits, glove leather, or lace leather. The split lace leather is just as durable as the grain leather, but it does not look quite so good. The sides may be split out of lime or out of pickle, and then tanned with the chrome liquor. Where yellow lace leather is wanted, it is colored with extract of fustic and some yellow dye before fat-liquoring. If white leather is desired, it is washed in hot borax water, and next in water acidulated with sulphuric acid, and then thoroughly in clean water before fat-liquoring.

A satisfactory method of tanning chrome lace leather is carried out as follows: The sides are de-haired, bated, and washed; they are then drummed with 2 lb. of pulverized alum and 4 lb. of salt for each 100 lb. of hides. The goods carry sufficient water from the last washing to dissolve the alum and salt. When they have absorbed the materials, they are allowed to press and drain, and, after having been partly dried, are split and shaved. The tanning is then completed by drumming the hides in one-bath liquor in the same manner as for chrome upper; they are finally washed and partly dried for fat-liquoring.

The fat-liquor is made as follows: 4 oz. of potash or other alkali is boiled in $\frac{1}{2}$ gallon of water; then 2 lb. of any good degras and 4 lb. of tallow are added, and the whole brought to a quick boil. The compound requires thorough cooking. Then 1 quart of neat's foot oil is added, and the mixture is stirred until the temperature reaches a little below boiling point. The fat-liquor, at 150° F., is applied to the leather, the above quantity being used for 100 lb.

When fat-liquored, the leather is struck out and oiled on the grain side with neat's foot oil, then stretched in frames until dry. After this it is moistened and staked, staking and drying being continued until the leather is soft and dry. Then it is painted on both sides with a light coat of paste made with tallow, starch flour, soap, and water boiled together; next it is dried again and finished. The chrome tannage permits the leather to be stuffed at a high temperature, thus ensuring thorough penetration of the stuffing grease, and the leather is made very elastic and durable, and peculiarly suitable for lace leather. Chrome lace leather does not harden, but remains soft and pliable until it is worn out. It does not burn when it goes over the pulleys. The tanning can be done in any of the various methods given for chrome leather.

**Semi-chrome leather.**—This class of leather, as the name implies, includes those leathers which are tanned partly by a vegetable tanning process and partly by a process of chrome tanning. The two processes may be carried out together, or consecutively, or the chrome process may be used as a re-tannage for vegetable-tanned skins. Usually the chrome process precedes the vegetable process, since this procedure gives the leather its characteristic properties.

Among the skins that arrive in the United States in a partly tanned condition are sheepskins from East India, South Africa, South America, and Australia. It is these skins, particularly those from East India, that are given the chrome re-tannage. The goods are sorted according to substance, tannage, etc., and are marked. After marking, the skins are equalized by splitting or shaving. The larger skins are split, and, if necessary, are shaved. Before splitting or shaving, the goods are dampened down by immersing the thick portions in warm water and finally the whole skin. Very light skins are dampened back by being treated with warm water in the drum for 10 minutes. Finally they are laid in a pile for a few hours to become uniformly soft and moist.

*Splitting and shaving.*—In splitting, the goods should be left thicker than the final product is required, and then shaved

down to the required substance. The flesh splits are used for welting purposes, heels, linings, etc.: the grains are de-tanned and then re-tanned with chrome liquor. Unless most of the original tannage is removed, the leather will be hard and unevenly tanned.

*Stripping the tannage.*—Stripping or de-tannage is accomplished by means of the milder alkalies. Caustic soda should not be used as it is too energetic. Borax may be used with advantage, because it acts gently and gives a smooth grain to the skins. For light skins, 2 per cent, and for heavy skins, 2½ per cent of borax is used, calculated on the weight of the drained goods. If washing soda is used, not more than 2 lb. should be taken for 100 lb. of leather. The drained skins are placed in the drum with warm water at 100° F., the drum is set in motion, and the borax or soda solution is run in through the hollow axle. The drum is allowed to run 30 minutes, which is usually sufficient to remove the greater part of the tannin. The washing should be continued until the skins have a soft and slippery or semi-gelatinous feel. When this has been accomplished, the liquor is allowed to run out and warm water is run in to wash the skins. This washing is continued until the water coming from the drum is clear, showing that all dissolved tannin is removed. In order to neutralize the alkali retained by the leather, ½ to 1 per cent of formic acid is added to the wash water. The progress of neutralization may be followed by applying a piece of blue litmus paper to a cut section of the skins; if the paper is colored a feeble red, the process is complete. A final washing with pure water prepares the goods for the chrome retannage.

**Vegechrome.**—Calf and kip skins may be tanned with "vegechrome" in a paddle-wheel tub by the following procedure:

*Pickling.*—Weigh the skins after washing from the bate.

*First pack.*—For each 100 gallons of water in the tub dissolve 40 lb. of salt. Then for each 100 lb. of skins add 1½ lb. of 66° Bé. sulphuric acid.

Start the paddle, throw in the skins, and allow the paddle to turn 3 hours. Then shut down the paddle and allow the skins to lie in the liquor until an hour before stopping for the night; then run one hour, and allow the skins to lie in the liquor over night. The next morning run the paddle one hour, and then haul the skins and either horse-up smooth or pile-down flat for 24 to 48 hours.

*Second pack.*—Strengthen the liquor by adding 10 lb. of salt and $1\frac{1}{2}$ lb. of sulphuric acid for each 100 lb. of skins. Then proceed same as for the first pack.

*Third, fourth, fifth and sixth packs.*—Strengthen the liquor by adding 8 lb. of salt and $1\frac{1}{4}$ lb. of sulphuric acid for each 100 lb. of skins and proceed as for previous packs.

*Seventh, eighth, ninth, tenth, eleventh and twelfth packs.*—Strengthen the liquor by adding 6 lb. of salt and 1 lb. of sulphuric acid for each 100 lb. of skins and proceed as for previous packs.

After 12 packs have been pickled, clean out the tub and start again.

This formula requires that each pack must contain enough skins to make a full load for the size of the paddle-tub used. If less than a full pack is to be pickled, a drum should be used.

*Tanning: First pack.*—For each 100 gallons of water in the paddle-tub dissolve 50 lb. of salt. Then for each 100 lb. of skins to be tanned dissolve 12 lb. of vegechrome as directed below.

Warm the liquor to 75 or 80° F. Start the paddle, and throw in the pickled skins. Never throw in the skins unless the paddle is running.

Take half of this vegechrome solution and add it to the contents of the paddle and run for one hour; then add the other half and run the paddle for the remainder of the day. Two hours before stopping for the night, warm the liquor to 85 or 90° F., and add 6 oz. of bicarbonate of soda or borax, dissolved in a little water, for each 100 lb. of skins. Allow the skins to remain in the liquor over night. On the second day run the paddle 2 hours in the morning and 2 hours in the

afternoon; warm the liquor again before stopping for the night and allow the skins to lie in the liquor over night. When the skins have been in the liquor 48 hours, they should be tanned, but if any doubt exists run them until they are.

When completely tanned, the skins are removed and horsed-up smooth or piled-down flat, and allowed to drain 24 to 48 hours.

Never start tanning in the paddle unless there is sufficient time before closing for the day to run it at least two hours after the last portion of the tanning solution has been added. If the skins are completely tanned, a piece cut off from the thickest part should stand boiling. If the piece cut off shrinks materially and becomes hard upon boiling, the skins are not thoroughly tanned and should be left in the tan liquor and run until the leather will stand boiling. There is no danger of over-tanning the skins by leaving them too long in the vegechrome.

*Second pack.*—Strengthen the liquor by adding 8 lb. of salt and 12 lb. of vegechrome for each 100 lb. of skins, as directed for the first pack.

*Third, fourth, fifth, sixth and seventh packs.*—Strengthen the liquor by adding 6 lb. of salt and 9½ lb. of vegechrome for each 100 lb. of skins, as directed for the first pack.

*Eighth, ninth and tenth packs.*—Strengthen the liquor by adding 4 lb. of salt and 8 lb. of vegechrome for each 100 lb. of skins, as directed for the first pack.

Two hours before stopping for the night of the first day, for each pack add to the liquor 6 oz. of bicarbonate of soda, dissolved in a little water, for each 100 lb. of skins.

After 10 packs have been tanned, clean out the tub and start again, as for the first pack.

*Dissolving vegechrome.*—Dissolve the vegechrome in boiling water, using one gallon of water for every 3 lb. of vegechrome. The best way to effect the solution of this material is to put the proper amount of water into a barrel or tank, insert a steam pipe, and bring the water to the boiling point. Then add the vegechrome to the water, stirring constantly

with a stick, and boiling vigorously until it is completely dissolved, which will take about 10 minutes. Allow the solution to stand until the temperature falls to 100° F. Do not put the vegechrome in water and then let it stand before boiling and dissolving.

*Neutralizing and washing.*—After draining from the tan liquor the required period, the skins are then thrown into the drum with a solution of antimonine (antimony lactate), using 4 oz. in 10 gallons of water not over 100° F. for each 100 lb. of skins. Mill in this solution for a half-hour, and wash the skins in running water for 10 to 20 minutes. Then add 10 gallons of water to the drum for each 100 lb. of skins, and in it dissolve 4 oz. of borax and run them in this borax water for 30 minutes. Then wash the skins in running water until neutral to the taste (1 to 3 hours, depending upon the thickness of the skins). The skins must be washed long enough to remove all acid and salt.

**Chrome-tanned wax calf leather.**—The tanner of chrome calfskins finds many having defective grain which can be re-tanned and finished into chrome wax leather. Heavy skins are more suitable for this leather than light ones, the light stock being more suitable for ooze leather. All skins from a medium up to 10 to 12 lb. can be worked into chrome wax leather, provided that they are free from butcher cuts on the flesh side. They are worked through the preliminary process in the same manner as those for chrome leather, being tanned with one-bath chrome liquor and shaved. After shaving, they are washed and tanned.

*Re-tanning.*—This consists in re-tanning the skins with hemlock extract, or with a mixture of hemlock and oak extracts, hemlock and quebracho extracts, or with other suitable tanning material. Two methods of re-tanning will be described:

The first liquor is a 5° bk. hemlock liquor in which the skins are hung 24 hours. This liquor is then strengthened to 8°, and the skins are left in it for 48 hours, after which the strength is increased to 10°, the skins remaining therein 48 hours. The

next liquor is at 14°, and the skins are transferred to it and remain in it 6 days. Handle them every 2 days, or give them a 16° liquor for 4 days and handle every 2 days; then they should be given 5 days in an 18° liquor, being handled every other day. Re-tanning is now complete. The liquors may also be made up of oak and hemlock extracts in the proportion of 3 parts of the latter to 1 part of the former. Gambier is about the only vegetable tanning material that does not lose considerable of its tannin strength by precipitation in the presence of salt. Synthetic tans do not lose their efficiency by precipitation, but quebracho, hemlock, and most other vegetable tanning materials do.

Re-tanning may also be done in a drum in the following manner: The first liquor is made of 3 lb. of hemlock extract, and 1 lb. of oak extract, and 5 lb. of salt in 25 gallons of water for 100 lb. of chrome leather. In this liquor the skins are run one hour, then they are piled-down for 24 hours. The second liquor may be the same as the first, the skins being run in it one hour, then piled-down for 24 hours. On the third day the skins are given the last re-tanning liquor, which is made up of 3 lb. of oak extract and 1 lb. of hemlock extract and no salt. The skins are run in this liquor 2 hours, then placed in piles for 12 hours. Re-tanning by hanging the goods in the liquor is doubtless the better method of the two. After the leather is fully re-tanned it should lie on a pile for 48 hours, and then be fat-liquored.

**Intestinal leather.**—This process makes leather from the intestinal membrane, which, on being bleached, has the appearance of ordinary glove leather or kid. It is, however, essentially different from such leather by the absence of pores, thus rendering it impervious to moisture and gases, and by its extreme thinness coupled with great toughness or strength of fiber. It is distinguished from gold-beater's skin in that it may be sewed, the seam being firm and the leather closing tightly around the thread, and also by its extreme pliability and softness. These properties render this leather peculiarly suitable for the manufacture of gloves for those whose occu-

pations render it necessary to protect the hands against infectious matter and poisonous solutions. The extreme softness of the leather permits free movement of the fingers, and its thinness gives the sense of touch full play. Unlike gold-beater's skin, it may be boiled without injury, so that a surgeon's glove made from it may be dipped into a formaldehyde solution and then boiled for the purpose of cleansing, disinfection, and sterilization, which is a matter of great importance.

This leather is applicable to a great variety of purposes. For example, it is exceedingly well adapted for ink ribbons; as a covering for balloons it has been found superior to the ordinary silk covering by virtue of its greater lightness, less bulk, pliability, softness, and imperviousness; it is also used for partitions in dirigibles; it can be dyed any color, and when dyed, may be used in place of ornamental papers. This material serves the same purpose as the outer peritoneal coating of the cæcum or blind gut of the ox, and is known as "gold-beater's skin," being used by the gold-beater in making gold leaf. In most of the slaughtering establishments in the United States and Germany this membrane is now removed from the intestine which it envelopes, and is supplied in this condition to the manufacturers of gold-beater's skin, or to gold-beaters.

In order to convert this delicate membrane into leather, all fatty substances and adhering impurities are first removed by the following treatment: The membranes are rinsed in warm water, preferably in three graded baths, each having a higher temperature than the preceding one; for example, 77, 86, and 95° F. One hundred membranes are next immersed, and left for about 5 minutes, in a bath composed of 10 grams of potassium permanganate dissolved in 3 liters of water and having a temperature of 80° F. They are then placed in a bath of 20 grams of sulphurous acid dissolved in 3 liters of water at 80° F. The skins must be left in this bath until they have swelled up and attain a pure white color, whereupon they are taken out and again submitted to three rinsings in warm water as above. They are now ready to be immersed in a soap solution or bath. This is preferably prepared by boiling about

½ kilogram (1.1 lb.) of good pure white toilet soap, such as white castile, in 1½ liters (2½ pints) of water, for 100 membranes. The temperature of this bath has first to be reduced to 95° F. by the addition of ½ liter of cold water. The membranes remain in this soap bath for several hours, until the soap has been completely absorbed; they are then put successively into two baths of warm water having a temperature of 80° F., for the purpose of completely washing them. The membranes are now ready for the tanning process, which is as follows: A solution is prepared by dissolving, for each 100 membranes, 100 grams of chromic acid, and 50 grams of alum in 1 liter of water at 95° F. The membranes are placed in a bath of 1 liter of warm water at 80° F., and the chromic acid solution is gradually added to the water, the skins being stirred in the bath. Preferably the following course is pursued: First, about a sixth of the chromic acid solution is added to the membranes, then after about 10 minutes a further eighth of the same, and after another 10 minutes a quarter of the original amount of the chromic solution, and finally after 20 minutes, the rest of the solution is poured into the bath containing the membranes. In this final bath the skins are allowed to remain for an hour, being constantly agitated or stirred. They are then removed and rinsed twice with warm water at 80° F. This completes the tanning process.

It is advantageous to immerse the tanned membranes in a bath composed of 500 grams of egg-yolk and 100 grams of glycerine added to 2 liters of water, and thoroughly mixed with it. The membranes remain in this bath for about 10 hours. They are then removed and drained by hanging over ropes, and are next placed on suitable frames and allowed to dry. After about 8 days they are stored in moderately damp chambers and are then drawn over their entire surface across crescent-shaped blunt knifes until they are smooth and pliable

The leather is now finished and may be used in this condition, but for many purposes it may be found desirable to finish or embellish it further. It can be dyed beautiful colors, and for this purpose may be immersed in a bath containing the

desired dye, such as aniline dye. A bath containing from 3 to 5 per cent of dye usually suffices. To this bath is added a mordant consisting of 4 cubic centimeters of acetic acid of 50 per cent strength. The leather remains in this bath for several hours. It is also claimed that by this process the leather, whether dyed or undyed, may be still further finished by passing it through calendering rolls. In some cases colored talcum powder may be sprinkled or dusted over it, and then calendered. It is also desirable in some cases to coat the undyed leather with a thin film of a composition prepared by mixing 8 parts collodion, 1 part castor oil and 1 part caoutchouc solution. Leather so coated is suitable for gloves, accordion bellows, and the like. When it is desired to obtain a thicker and stronger leather, which, however, is not so well adapted for dyeing, a tanning bath consisting of 100 grams of zinc sulphate, 40 grams of alum and 50 grams of wheat-flour properly mixed with 1 liter of water, may be used to tan 100 membranes, the other conditions and steps of the process remaining the same. This tanning bath is used instead of the chromic acid bath described. This treatment yields white, lusterless leather of greater body than that produced by the chromic acid method. This process was patented by Bruno Trenckmann, of Berlin, Germany, who also has a patent on the following process:

*Parchment-like skin.*—In the process as usually carried out, the peritoneal membrane of the gut, after having been cleaned of fat and soaked in a bath of soap, is immersed in a bath of zinc sulphate, barium chloride, or any other similar mineral salts which are able to produce pigments insoluble in water, by double transposition with any organic salts, acids, or bases. This process consists of alternately treating the skins in such baths at certain definite temperatures. For example, the gut membranes are first rinsed from 5 to 10 minutes in a solution of zinc sulphate or other mineral salts of 15° Bé., and at a temperature of 40° F. They are then put into a solution preferably of sodium carbonate of about 15° Bé. and at the same temperature, and are treated therein for about the same pe-

riod, raising the temperature to 60° F. They are then returned into another solution of zinc sulphate and then into a solution of sodium carbonate. This treatment is repeated once or twice more until the skins have absorbed a sufficient amount of the pigment, which is usually attained after two or three treatments.

By this process a parchment-like, clear white, or well colored, product is obtained, which may come into contact with water and when again dry, will appear as before. The product is capable of being extended when soaked, and will again shrink while drying, thus making a tight cap, perfectly air-tight, so desirable for closing bottles of all kinds.

**Leather for organ pipes.**—Leather made by the following process is distinguished by its fineness, suppleness, lightness, and durability. Such properties are required for many industrial purposes, particularly for fitting organ pipes, and in the manufacture of bellows and the like; and generally for purposes where it is desired to have an air-tight, light, and flexible material. The leather hitherto used for such purposes was usually not air-tight or sufficiently flexible, while rubber sheets or fabrics impregnated with a solution of rubber, although air-tight, are difficult to fit snugly because they are not sufficiently soft. They have also the serious drawback of being liable to deteriorate and lose their flexibility, thereby becoming brittle under the influence of cold. This is of great importance in church organs which are not heated during the winter. This leather has none of these disadvantages, and is therefore suitable for various purposes. It is manufactured from the cæcum or blind gut of the animal. This outermost skin of the blind gut has hitherto been deprived of its fat and dried, and used as the so-called gold-beater's skin. It has been proposed to subject it to a tanning process, but the leather obtained in that way alone is not sufficiently air-tight and durable.

By means of this process, the blind gut skin, well cleaned and washed with potash or the like, is first tanned by mineral salts such as chrome-alum, etc., or with vegetable products. In practice, it has been found that for 200 skins of maximum

size, 400 grams of zinc sulphate with 10 liters of water is suitable as a tanning solution; or about the same quantity of chrome-alum may be used. The skin is then filled in a bath of egg-yolk, flour, or the like, and permitted to remain therein until it is thoroughly impregnated, whereby it is made thicker and stronger. This bath is made by adding a small quantity of flour to about 1 liter of egg-yolk. The skins are then rinsed, stretched, and dried. The drying is effected by placing two skins, one on top of the other, and allowing to dry together in close contact. During this drying process they adhere firmly to one another without any glue or cement being used. The best plan is to place together the grain or outermost sides of the two skins. More than two skins may be superposed, in which case the similar sides are placed in apposition.

When a multiple skin treated in this manner has become sufficiently dry it is de-greased or deprived of its fat by treating it with benzine, being rubbed and kneaded at the same time, whereby it is rendered soft and supple. This treatment is necessary to remove the oil incorporated in the skin by treatment with the eggs, and make the leather soft and capable of being cemented to wood and metal. This property renders it suitable for gluing or piecing together, so that large pieces of any size may be made from small pieces, and it can be cemented to other materials, such as wood, etc., which is of importance for organ pipes and other purposes. This process, as stated, includes the process of tanning the stock, but if untanned skins are subjected to the other steps of the treatment —filling, superposing, and washing with benzine—a product is obtained having many advantageous characteristics over the untanned skins previously known.

# CHAPTER VII

## IRON TANNAGE

THE subject of iron tannage has been much discussed, and many attempts have been made to obtain a satisfactory tannage with this element. Iron belongs to the same periodic group as aluminum and chromium, and naturally one would expect it to lend itself to the same general reaction as the other two elements. Of the three elements, iron is the most basic, and, unlike chromium and aluminum, has no acid-forming property. The tanning quality of iron, however, does not depend upon this property, but rather upon the fact that it forms basic compounds when its salts are treated with an alkali. Although chromium and aluminum also form basic products, these compounds are more stable than that produced from iron. Any attempt to produce a compound of the formula $Fe_2(OH)_2SO_4$ will result in the precipitation of the hydrated oxide $Fe_2O_3.H_2O$ which is a yellow powder and entirely inert as a tanning material. This hydrated oxide differs also from the corresponding aluminum and chromium oxides in that it rapidly passes through the colloidal range and becomes a crystalline substance.

In a series of papers which appeared in the Journal of the American Leather Chemists' Association, beginning in the February issue of 1921, Dr. Daniel D. Jackson and Dr. Te Pang Hou set forth the early history of this important subject, and through their investigations have shown conclusively why so many attempts to produce iron-tanned leather have failed. They have also pointed the way to new processes which open up a new field for investigation and should warrant every consideration.

Having had Dr. Hou as a student at one time, and knowing the painstaking care with which the investigation was conducted, the author can vouch for the thoroughness of the clas-

sic research, and desires to give him credit for the following information on iron tannage:

**Research in iron tannage.**—Attempts to use iron salts as tanning agents date back to the time when efforts were first made to find a substitute in the form of metallic salts for vegetable tannins. In the course of more than a century, efforts were repeatedly made and interest was continually revived to make iron tannage a commercial success, but without reward, in spite of the great promise that inspired such investigators to make a most determined effort. Within the last decade, partly on account of the great war, new interest has been given to iron tannage, and the properties and behavior of iron salts as tanning agents are gradually becoming better understood.

The history of iron tannage begins from the latter part of the 18th century. Many of these early investigators were men who also helped to establish the present-day chrome tannage.

In 1770, J. Johnson, an Englishman, patented a process of tanning, using ferrous sulphate with an acid (sulphuric acid, hydrochloric acid, or nitric acid). The pelt was tanned in three operations, in the middle of which a vegetable tannin was used.

In 1794, Sam. Ashton, another Englishman, recommended for tanning a mixture of iron oxide and sulphuric acid, calcined iron ore or iron ocher with pyrite, copper ore, and zinc. The period of tanning was given as from 5 to 7 weeks. Some alumina was added for calfskins.

In 1805, Sigmond Hermbstadt, in his book on leather tanning, explained that solutions of metallic acid baths had similar action on the pelt as oak tannins. Among other salts he mentioned the red iron sulphate, in which not only the grain of the pelt was affected, but the pelt was virtually converted into leather if soaked in it for some time. He prepared his iron tan liquor by heating ferrous sulphate to a dry yellow substance which was dissolved in 20 times its volume of boiling water, and on cooling, the clear yellow-red solution was decanted for use. He also treated iron oxide with acetic acid;

or oxidized ferrous sulphate with concentrated nitric acid, or with a mixture of concentrated nitric acid and sulphuric acid. Sole leather as well as upper leather could be made in this way, but it was de-tanned in contact with water.

In 1842, d'Arcet, a Frenchman, tanned the hides in a ferric sulphate solution, but the sulphuric acid set free gradually destroyed the hides. In the same year, Julius Bordier, of London, patented a process (British patent 9,219, 1842) of oxidizing ferrous sulphate with nitric acid and sulphuric acid, and with manganese dioxide and sulphuric acid. It was said that he had attained some success.

In 1853, Hylten Cavalin, employed a tanning liquor containing 10 lb. of potassium dichromate and 20 lb. of alum in 180 lb. of water. The hides were tanned in this liquor for 4 days, and were next placed in a 10 per cent ferrous sulphate solution for 12 hours with frequent stirring. The acidity relation of these two liquors was not properly adjusted, and the iron was not completely oxidized. The leather obtained was hard and brittle.

In 1855, Rene de Kercado Molac and Jean Daniel Friedel, both of Strasbourg, France, patented a process whereby the hides were tanned in a basic ferric sulphate solution which was later neutralized with metallic oxides, such as ferric oxide, alumina, and zinc oxide to remove the sulphuric acid liberated. They prepared the liquor with ferrous sulphate, manganese dioxide, and sulphuric acid, and added ferric acetate in varying proportions to the liquor. A. E. L. Bellford, of London, patented their process in England. In this British patent (January 12, 1855) it was stated that the leather treated by other mineral processes is "liable to tear in length of time on account of the great quantity of acid remaining in the leather corroding the animal fibers."

Dr. Frederick Knapp, Professor at the Polytechnic School of Braunschweig, Germany, made a thorough investigation on these mineral tannages and published the results in "Die Natur und das Wesen der Gerberei und des Leders" (Munich, 1858), and also in an article, "Uber Gerberei und Leder," in Dingler's

Polytechnische Journal, vol. 181, p. 311 (1866). He made a satisfactory explanation of the tanning action. He had in mind the possibility of reducing the length of time needed in the vegetable tanning process, and eliminating costly materials such as egg-yolk and flour used in alum tannage. He recognized the plumping effect upon the hides by the acid liberated during tanning, and the stiff and brittle character of the leather obtained. He recommended neutralizing the tan liquor during the process of tanning with sodium carbonate or caustic soda, and pointed out the advantages in so doing, namely, that the hides were more richly tanned, that the harmful acid effect was prevented, and that neutral electrolyte NaCl (in $FeCl_3$ liquor) was produced in the tan liquor. His British patent 2,716 (1861), through John H. Johnson, covered iron, chrome, manganese, and other metallic salts in combination with fatty acids to form insoluble metallic soaps, so that the iron in the pelt might not be washed out. He also mentioned the use of similarly insoluble silicates of alumina and alkaline earths. According to his German patent No. 444 (1887), he prepared his liquor by adding nitric acid in excess to oxidize completely a boiling ferrous sulphate solution when brown nitrogen dioxide ($NO_2$) fumes were seen. After all of the iron was oxidized, he introduced more ferrous sulphate into the resulting solution, as long as $NO_2$ fumes were evolved. The liquor, after evaporation, becomes a varnish-like liquid. Judging from this description, his liquid must have been too alkaline through the loss of the nitric acid by boiling. In his additional German patent No. 10,518 (1879), he used sodium nitrate and sulphuric acid for oxidation instead of the nitric acid. This method is far more economical, and involves no danger of losing the acid by heating, so that the acidity of the resulting liquor is under control. Furthermore, a neutral salt, $Na_2SO_4$, is produced in the tan liquor.

In 1864, F. Pfannhauser obtained a patent for the preparation of a basic ferric sulphate solution and its use in tanning. He roasted ferric sulphate to a red heat with continuous stirring until it was reduced to a red powder, which was then

thrown into water while still hot. Most of this powder was said to be dissolved. The colloidal matter was allowed to settle, and the supernatant liquid was drawn off for preparation of tan liquors of varying strength. The skins were tanned counter-currently and, when tanned, were placed in a soap solution.

In 1877, Paesi proposed to use a ferric chloride solution together with salt at 20° C. in the ratio of 100 parts of water to 10 parts of $FeCl_3$ and 5 parts of salt.

In 1881, E. Harcke obtained a German patent, No. 19,633, according to which the pelt for making sole leather was treated with a mixture of a resinous body (such as rosin), coal-tar creosote or carbolic acid, and an alkali, in water, until thoroughly penetrated. The pelt was then tanned, first in an aluminum salt solution and then in a ferric chloride solution, or other ferric salt solution. For making upper leather, the hides were previously limed, and if softness and porosity were desired, the rosin could be omitted.

In 1881, W. Eitner patented a process (Austrian patent No. 6,775) using a mixture of a basic chromic sulphate and ferric sulphate solution. This process was used in Graz, Austria, and the product known as "patentleder, marke elefant." By changing the ratio of the chromic salt to the ferric salt, different gradations of color—from yellow (of the iron) to gray (of the mixture) and to green (of the pure chrome)—were obtained. When a mixture of the ferric and chromic salts was used, the leather was colored black with logwood alone; when chromic salt alone was used, the leather was colored black with logwood and an iron "striker." When a yellow color was not desired in the product, chromic salt alone was used for tanning. Leather obtained in this way was stuffed, after sammying, with mixtures of train oil, castor oil, stearine, tallow, mineral oil, etc., with sodium bicarbonate, soap, borax, casein, etc., as emulsifying agents.

In 1886, John W. Fries, of Salem, North Carolina, patented a process of tanning (U. S. patents No. 343,166 and 343,167), using ferrous carbonate (or ferrous sulphate), so-

dium carbonate (or sodium bicarbonate), and sulphuric acid. The skins were tanned first in a dilute liquor for 2 or 3 days, and then in a more concentrated liquor for the same length of time. A small amount of liquor might be added. After the tanning operation the skins were hung in the air to get the iron oxidized. For currying, he used tallow with a paraffin oil, lard, or cotton-seed oil; and later, in his patent No. 343,-167, he recommended an alcoholic solution of castor oil.

In 1892, Paul F. Reinsch of Erlangen, Bavaria, patented a process (German patent No. 70,226) using a liquor prepared by mixing 10 kg. (kilogram) $FeCl_3$ dissolved in 40 liters of water, with 4½ kg. crystalline $Na_2CO_3$ dissolved in 20 liters of water, thus yielding a dark brown solution. He called it ferric chloride-sodium chloride liquor, which he used for making different kinds of leather, either alone or in combination with alum-sodium chloride tannage. In 1912 he obtained another German patent, No. 265,914, on the use of ferric chloride and magnesium carbonate. He prepared the liquor by dissolving 1 kg. of ferric chloride in 4 liters of water, to which was added a suspension of 225 grams of $MgCO_3$ in a liter of water. To this mixture he added a solution of 8 per cent aluminum chloride. Evidently his idea is to bring about the required basicity by $MgCO_3$. The $AlCl_6$ present was probably meant to help keep the basic ferric chloride in solution.

J. Bystron, and Karl, Baron von Vietinghoff, obtained a number of German patents, No. 255,320 et seq., in 1911, a British patent, No. 13,952, in 1912, and two U. S. patents, No. 1,048,294 in 1912 and No. 1,061,597 in 1913. They employed nitrogen dioxide ($NO_2$) and nitrogen trioxide ($N_2O_3$) for the oxidation of iron. The nitric oxide ($NO$), from the oxidation reaction is collected and re-oxidized by contact with fresh air to $NO_2$ and $N_2O_3$, which gases are used again for oxidation. They thus proposed to utilize the $NO_2$-$NO$-$NO_2$ cycle, making the oxides of nitrogen virtually catalytic agents for the oxidation of iron. In British patent, No. 13,952 they observed considerable precipitates formed in the tan liquor and on the skin. According to them the presence of large

quantities of an acid causes the formation of a highly acid and not completely insoluble iron oxide in the skin, so that the leather made is brittle and cannot be stored. In this patent and also in the U. S. patent No. 1,048,294 they proposed placing the skin in a ferrous salt solution, and oxidizing the ferrous iron by passing in $NO_2$ gas from outside or by liberating $HNO_2$ from a nitrate added to the liquor. Thus they attempt to complete the oxidation reaction and the tanning operation in a single operation. It is true that $HNO_2$ (from a nitrate and an acid) has sufficiently high oxidation potential to oxidize ferrous iron to the ferric state, but in order to oxidize all the ferrous iron into the ferric state completely, the presence of much acid in the solution and of an excess of the oxidizing agent is needed. If the oxidation by $HNO_2$ or oxides of nitrogen is to take place simultaneously with the tanning operation at the low acidity necessarily present in the tan liquor, probably there will be much difficulty in getting all of the ferrous iron completely oxidized. Bystron, in U. S. patent No. 1,061,597, patented the use of a neutral alkali salt such as $Na_2SO_4$ or NaCl for treating the iron-tanned leather. He claimed that by this treatment a more insoluble basic ferric salt of a light color is formed in the leather, thereby yielding a soft, elastic, and non-brittle product.

In 1917, O. Rohm obtained British patents No. 103,827 and 104,338 for a combination tannage using formaldehyde and ferric chloride, or formaldehyde and a mixture of ferric chloride and chromic chloride or aluminum chloride. In his patent No. 103,295 (not accepted) he mentioned the use of ferric alum mixed with vegetable tannins to form iron tannate (ink) for tanning. In his patent No. 103,827 he recommended tanning with formaldehyde in sodium bicarbonate solution, followed by a tannage with a ferric chloride solution; a mixture of ferric chloride and chromic chloride; a mixture of ferric chloride and aluminum chloride; a ferric chloride solution and then vegetable tannins; or a ferric chloride solution with an alkaline sulphide. He also mentioned the treatment of the skin with an iron precipitant, such as $NH_3$, alkalies, or alkal-

ine salts; or phenols, naphthols, organic carboxylic acids, vegetable tannins; or soap, sulphide, polysulphide, and the like. He mentioned that the leather obtained would not become slippery when wet, as is the case with a chrome leather. In his patent No. 104,338 he stated that the aldehyde tannage could be advantageously used to follow iron tannage after neutralization, or together with neutralization. When the aldehyde is introduced with the neutralization after the iron tannage, there is, according to Rohm's observation, an advantage that the grain-drawing, so common in mineral tannage, will be prevented. His thought seems to be along the line that since aldehyde tannage is carried on in an alkaline solution, the introduction of the aldehyde tannage after the iron will serve also as a neutralization operation to fix the iron in the pelt. But since formaldehyde is a tanning agent alone, to what extent the iron salt has contributed to the tannage it is difficult to tell.

In his German patent No. 306,015 (1918), Emil Kanet introduced an interesting feature in the mode of tannage. He derived the tanning action by the hydrolysis of a ferric salt. He treated the pelt at a low temperature with a ferric salt solution of such a basicity that it would be unstable at the ordinary temperature; and, after allowing the liquor to penetrate the pelt, raised the temperature to bring about hydrolysis. To illustrate: He placed the skins in a basic ferric acetate liquor containing from ½ to 2½ per cent of $Fe_2O_3$, preferably with the addition of some salt or other electrolyte such as sodium acetate. After the skins were penetrated by the tanning liquor he transferred them to a fairly concentrated salt solution at a temperature of from 45 to 60° C., or exposed them to heat in a warm chamber. The tanning action was completed in a short time, but the stock was further laid aside for some time to fix the iron. The acetic acid set free under the influence of heat can be recovered from the skins by pressure. If a filling material such as flour is used with the tan liquor, it is, according to him, fixed in the leather with the basic ferric acetate. Other mineral salts such as chromic salt can be mixed with the iron. The advantage claimed is that

at a low temperature a more basic ferric salt solution can be used, and that the oxidizing activity of the ferric iron towards the skins is lessened.

In his Swiss patent No. 75,775 (1918), W. Mensing recognized the ease with which ferric salt in solution is decomposed, and mentioned the effect of ferrous iron on the skin when the ferrous salt is present in the tan liquor. He recommended the use of an excess of an oxidizing agent and patented the use of a chlorate (Na, K, or Ba) as the oxidizing agent. He also recommended a preliminary treatment of the skin with borax or a basic aluminum or chromic salt solution for the use of a slightly more acid or neutral ferric liquor. According to his idea, the tanned stock should not be washed with water, but only wrung or pressed to get rid of the excess of the tan liquor. On drying, the stock is oiled with a mineral oil, paraffin, or ceresin, and then washed. To avoid reaction of the iron in the pelt with vegetable tannins, he recommended fixing the iron by treating the leather with a slightly alkaline solution before vegetable re-tanning. He advocated the bleaching of the leather by de-tanning the surface layers by means of a reducing agent and then an acid. On the whole, his patent marks a better understanding of the properties of the iron tan liquor and the process of iron tannage.

Vittorio Cassaburi, in the articles, "Notes on the Tannage of Skins with Iron Salts," published in the Journal of the American Leather Chemists' Association in 1919, gave the results of a series of his experiments, using a basic ferric sulphate solution (from the oxidation of ferrous sulphate with a mixture of nitric acid and sulphuric acid); a solution of a mixture of basic ferric chloride and sulphate (from the oxidation of ferrous sulphate by nitric acid and hydrochloric acid); a basic ferric chloride solution, and a basic ferric acetate solution. He employed a strength of iron liquor containing 1 per cent of $Fe_2O_3$ on the weight of the pelt in a little over 4 times the weight of the water as of the weight of the pelt. According to him, 7.88 per cent of $Fe_2O_3$ in the leather on the basis of the dry weight is sufficient to convert the pelt into leather.

He stated that he had started with a tan liquor having such a basicity as to correspond to the formula $Fe_2(SO_4)_3(OH)_2$ but his iron and basicity determinations of the liquor showed that the liquor he used was more acid than this, the basicity of his first liquor (basic ferric sulphate) being only one-half of this value, and that of his second liquor (a mixture of basic ferric sulphate and chloride) less than a half of this value. (We have found that a sulphate liquor having so high a basicity as to correspond to $Fe_2(SO_4)_2(OH)_2$ is too alkaline for use.) Throughout the course of tanning he strengthened the liquor with fresh portions of the strong liquor.

In his work, Dr. Hou devoted much time to the study of proper methods for the oxidation of the ferrous to the ferric conditions, and made a careful series of tests on the exact point of neutralization. All of this work is set forth in his treatise referred to early in this chapter, so it is hardly necessary to repeat it in this volume. Dr. Hou's conclusions may best be stated in his own words, showing that iron tannage has possibilities when the processes are conducted along scientific lines:

The character of the iron tannage seems to lie between that of alum and chrome tannage. Iron seems to yield a more permanent tannage (towards water) than alum, but like the alum tannage, iron-tanned leather does not resist the boiling temperature of water. If we take the critical temperature as that at which the sample under water begins to shrink or to draw together under the influence of heat, that point generally lies between 160° and 175° F. In the case of a re-tanned leather (in fish oils or vegetable tannins) a somewhat higher test may be obtained; but in no case can an iron-tanned leather stand boiling, unless a considerable portion of the tannage is due to chrome as in the case of the chrome-iron joint tannage.

It has often been reported that iron-tanned leather produces a brittle grain, and rots on storing, but to do justice to the iron tannage it must be declared that an iron-tanned leather, properly tanned, is not brittle on the grain and does not deteriorate on storage. Samples of leather which have now been kept for more than 10 months show no sign of deterioration. Sometimes the product obtained is somewhat stiff and "flat," but this should not be ascribed to the inherent properties of the tannage. The strength, the fullness, the elasticity, are, in our opinion, a matter of proper tannage and not dependent upon the nature of the tannage.

As a considerable amount of salt (4 to 5 per cent of the weight of the pelt) is needed in the liquor, and much of it is formed from neutralization, it is important to rinse the tanned stock after neutralization to wash off most of the neutral salts present ($NaCl$, $Na_2SO_4$, etc.); otherwise their presence in the leather may cause dampness or even salt stains or spues. Iron tannage is much affected by the presence of grease or any imperfec-

tions in the skins, and when such is the case, unevenness of color and other irregularities are liable to show up on drying; hence the necessity of uniform softening of the pelt and of de-greasing.

Iron-tanned leather generally runs high in ash. The leather often has a harsh feel, due probably to the presence of a large amount of iron oxide ($Fe_2O_3$) in the leather. On account of this harsh feel it is generally advisable to give the leather a somewhat heavy fat-liquoring or an oil treatment. The use of flour, egg-yolk, etc., may be practiced, if desired. At the present stage of our knowledge it seems that to produce a satisfactory tannage, at least for a light leather, an amount of iron, calculated as $Fe_2O_3$, not less than 4 per cent of the weight of the air-dried sample should be present.

The iron-tanned leather compares favorably with other mineral-tanned leather. The red-yellow or brown-red color of the tannage, however, is for some purposes an undesirable feature. The chemical activity of iron, forming dark colored compounds in the leather, is another drawback. But even with all these limitations there is much to be said in its favor. There are certain classes of goods in which these features are of no consequence and the saving in the cost of production is considerable. True, there are difficulties in connection with the tanning operation and subsequent treatment of the leather—difficulties which in other tannages either do not exist, or are less serious. But the process, like any other new process, necessitates a new set of conditions. To summarize, the following main factors may be mentioned:

I. Completeness in the oxidation of iron and maintenance in its ferric state by using an excess of a proper oxidizing agent, and by means of an after-oxidation.

II. Adjustment of proper basicity by the addition of a proper amount of an alkali, a basicity between the ratio of one OH-equivalent to every 5 equivalents of the mineral acid radical present, and that of one OH-equivalent to every 3 equivalents of the mineral acid radical present, being the proper range for tanning.

III. Gradual neutralization to be effected so that iron may be uniformly fixed in the pelt throughout its thickness.

IV. Drying to the crust state before subsequent treatment to minimize the chemical reactions between the iron in the stock and the substance employed, which would react with iron to give an undesirable color.

It might be added that the subject of iron tannage presents a broad and unexplored field, and this study is far from being exhaustive. Other phases could have been taken up and it is hoped that this work will serve as an indication for much that remains to be done.

# CHAPTER VIII.

## VEGETABLE-TANNED LIGHT LEATHERS

The processes employed in the production of leather with vegetable tanning materials vary according to the kind of leather being manufactured, and with the nature of the materials employed. Time is also an important factor, and several months may be consumed in the case of sole leather, while with light leather the operation may be completed in a few hours. In dealing with these processes the study of light leathers will be considered first.

**Vegetable-tanned sheepskins:** *Quebracho tannage.*— Soft and well-tanned leather is made by tanning pickled sheepskins with quebracho extract. This tanning material is used alone with good results; it is also used in combination with chestnut and hemlock extracts. It is recommended that for the quebracho tannage the skins be pickled with formic acid and salt. When so pickled and carefully tanned, they have fine, soft grain, and there is no danger or difficulty in dyeing owing to lime spots. The natural grease should be removed by pressing the skins while they are in the pickled condition. It is also advisable to press them after they have been colored in the first quebracho liquor; they are then put back into the liquor and tanned thoroughly. The quebracho liquors should always contain salt. A quantity of the extract is boiled with water in a barrel, this forming a stock solution from which the tan liquors are made and strengthened.

To make the first liquor, add enough of the dissolved extract to water in a paddle to make a 3 or 4° bk. liquor. Let the skins turn in this liquor until they have assumed a uniform color and are well struck with the tan; then either strengthen the liquor, or pass the skins into a fresh and stronger liquor of 6 or 8° strength. After several hours the liquor is strengthened to 10°, and the skins are left therein

until they are completely tanned. The skins can be taken out of the paddle after the grain is set, and tanned out in a drum, thus saving time.

When it is fully tanned, the leather is washed and fat-liquored with a solution of sulphonated oil or some other fat-liquor, and dried; or it is dried and fat-liquored after dyeing. The skins can be tanned by being tacked to wooden strips or frames, and suspended in the liquor The tanner must be careful to avoid drawn grain by having the liquors too strong at the beginning. The liquor for the fresh skins should not be over 6 to 8° strength; but as soon as the grain is well set, the liquor can be strengthened. Colored and embossed, the skins make fine leather for pocketbooks and bags, sweat-bands for hats, and other purposes.

*Hemlock and quebracho tannage.*—In this process the skins are started in weak hemlock liquor, and then passed into a stronger liquor composed of hemlock, oak-wood and quebracho extracts, care being taken to handle the skins every day until they are tanned. Hemlock and quebracho extracts combined form a good tan for sheepskins. The liquor may be two-thirds quebracho and one-third hemlock. The resulting leather is tough, firm, and pliable; and has good color which is more satisfactory in every way than the color of hemlock leather.

*Hemlock tannage.*—Large quantities of sheepskins are tanned with hemlock-bark extract, and used for various purposes. The tannage fills and plumps the skins, and the leather has good color on which it is easy to apply dyes. Hemlock-tanned skins are finished in the natural color of the tan; they are dyed black or colored, and are finished with a smooth or an embossed grain for fancy leather purposes.

Pickled skins should be pressed for removal of the grease, and drummed in warm salt water to soften and open them out, also to separate and prepare them for the tannage. There should be considerable salt in the liquors. The tanning is begun in weak liquor, which is gradually strengthened until the skins are tanned through. When tanned, the leather is

horsed-up to drain, dried, then colored and finished. A mixture of oak and hemlock liquors produces light-colored, well-tanned leather.

*Combination tannage.*—A mixture of gambier, alum, and salt can be recommended for making a soft, durable leather from sheepskins. The skins are limed and drenched in the usual manner, and are then placed in gambier liquor in a paddle. From 3 to 5 lb. of gambier is sufficient for a dozen skins, according to size and thickness. After the skins have started to absorb the gambier, from 8 to 16 oz. of alum and 8 oz. of salt for each dozen skins are added to the liquor, and the paddling is continued until the tannage is completed. The leather is then washed in warm water to remove the adhering tan, and then treated with acid fat-liquor, dried, wet-back, colored or blackened, dried again, and finished.

After the alum and salt are added, it is customary to put the skins and tanning liquor into a drum, and run a few hours or until the skins are thoroughly tanned. Some soluble oil may also be added to the liquor and applied to the leather toward the end of the tanning process. Excellent leather is also made by taking the skins out of the gambier liquor when they are well struck through, striking them out, and then drumming them in a paste of water, flour, alum, salt, and either egg-yolk or sulphonated oil, drying, and then coloring. Quebracho extract may be used in place of gambier, with equally good results. The color of the tanned leather can be greatly modified by adding a solution of fustic or other dyewood to the gambier liquor. The entire process can also be reversed. The skins can first be drummed in alum and salt, dried out, and staked, and then re-tanned with gambier. For glove leather, flour and oil may be added to the alum and salt liquor, the skins drying out soft and full.

Heavy skins can be tanned with gambier, split, and shaved, and then re-tanned with gambier, alum, and salt; they can also be alum-tawed, sammied, and shaved, and then re-tanned in a drum with gambier or quebracho. There are numerous variations of the process, these few suggestions being suffi-

cient to give some information about methods which may be used. After the leather is dry, it can be colored, and, if not previously fat-liquored, drummed in acid fat-liquor or an emulsion of oil and soap, dried, staked, and finished. The product is a soft and durable leather, which is suitable for gloves, linings, and various other purposes.

*Sumac tannage.*—Sumac makes soft, light-colored leather which can easily be colored and finished in any desired manner. The tannage is done in paddles; the skins are then dried and finished. The first liquor is rather weak and mellow; and as the tannage proceeds, the liquors are stronger and are warmed. A mixture of oak bark and sumac is also sometimes used; and a shorter tannage is obtained by drumming the skins with the tanning liquor after the grain has been set in a paddle.

The use of sumac after the regular tanning process is complete is for the purpose of preparing the leather for coloring. When the skins are completely tanned, they are horsed-up over night and are then placed in sumac liquor. This is prepared by adding water at 122° F. to 25 lb. of best Palermo sumac. The liquor should be cooled to 90° F. before the skins are put in, then they should be stirred more or less and left in over night, drained, set out, and dried. Sumacking can also be done in a drum. If soft leather is wanted, the skins can be run in a solution of sulphonated oil before they are dried. When dry, they should be kept in storage-rooms for some time before being colored and finished.

Well-tanned leather is made by a tannage of gambier and sumac. The skins are put into a 10° bk. liquor slightly acidified with acetic acid. After they have been in this liquor for a few hours they are placed in another and stronger liquor, and from this they are passed into a third and still stronger liquor to which acetic acid and oak-wood extract have been added. From this third liquor the skins are passed into the sumac bath, and are then oiled and dried out.

The application of an alum or kid tannage to skins tanned with gambier or quebracho makes fine, soft dongola leather.

For 200 average skins, a mixture is prepared from 5 lb. of alum, 9 lb. of salt, 24 lb. of flour, 10 lb. of egg-yolk or a corresponding quantity of sulphonated oil and 8 gallons of water. The alum and salt are dissolved in part of the water, then the flour is stirred in. The egg-yolk or the oil mixed with warm water is next added, and the whole mixture is thoroughly stirred. The skins are drummed with the mixture for an hour, then dried, colored, and finished.

*Tanning with alum, sumac, and oak bark.*—A soft, light-colored skin which can be used in the natural color of the tannage, or colored any desired shade, is made by tanning with alum, Glauber's salt, common salt, sumac, oak bark, nutgalls, and acid.

The pickle should be removed from the skins by drenching them with whiting and salt, followed by washings in two baths of warm salt water. To make the tanning liquor, dissolve 6 lb. of alum, 3 lb. of Glauber's salt, and 4 lb. of common salt in 5 gallons of water; and in another tub, boil 5 lb. of ground sumac, 3 lb. of oak bark, and 1 lb. of ground nutgalls, in 5 gallons of water. Mix the two solutions, then strain while the mixture is hot. A small quantity of formic acid is added to preserve the color.

The liquor is used lukewarm and the skins are drummed with it until they are tanned, then allowed to drain 24 hours. They are next struck out on both sides and oiled with neat's foot oil, then dried A solution of sulphonated oil may be used instead of neat's foot oil; the skins can be drummed in it, or it may be applied by hand. The skins tan quickly, and when worked out can be colored any shade or left in the natural color of the tan. The leather is durable and quite moisture-proof.

*Tanning with chestnut extract.*—Sheepskins, prepared as for any other tannage, may be tanned by being hung in chestnut liquor, or drummed in liquor made direct from the extract, or from a mixture of chestnut and quebracho extracts. If the skins are intended to be colored after they are tanned, it is best to tan them direct in the extract liquor, and then

re-tan them with sumac. Stock to be run in the natural color is usually struck in the combination liquor, giving the shade desired. With very thin skins, the main requirement of the tanning material is that it be clean, bright, and quick in action. Tanning may be started in a paddle and finished in a drum, the leather being then dried, treated with sumac, colored, fat-liquored with acid fat-liquor, dried, and finished.

*Tanning with sumac, alum, and salt.*—Sheepskins may be tanned in sumac liquor and then placed in a solution of alum and salt for one day. Taken out of the latter solution, the leather is rinsed off, struck out, and oiled with sulphonated oil, hung up, and dried. Coloring can then be done with artificial dyestuffs—basic or acid—the skins are again dried, worked out soft, and finished.

*Quebracho-tanned sheepskins.*—The pickled skins, being weighed, are placed in the mill and a solution of 30 per cent of quebracho extract on the weight of the stock is prepared at a concentration of 30° bk. To this solution is added 10 per cent of salt on the weight of the stock, and the whole added to the stock in the mill. The mill is now run for 1½ to 2 hours, or until the stock is tanned. The plugs being drawn, water is turned on, and the stock is washed until perfectly clean. If desired, washing may take place in a separate mill, and a new lot of skins run in the spent liquor for half an hour to utilize the unabsorbed tan. The plugs being drawn, a new liquor of 25 per cent of quebracho at 30° bk. with 10 per cent salt will be a sufficient quantity to complete the tannage. The plugs are then returned, the above liquor is added, and milling continued for 1½ hours. The washed stock is now fat-liquored with 1 per cent of anhydrous turkey red oil at a temperature of 110° F. for 30 minutes, washed again, set out, shaved, and hung up to dry. When dry, it is de-greased, buffed if necessary, and colored.

**Skivers.**—A skiver is the tanned grain side of a split sheepskin. The skins are split either after they have been limed or pickled. The grains are then tanned the same as whole skins with sumac, bark, alum, or some other tannage.

Skivers are used in the manufacture of leather goods, for linings, hat sweat-bands, etc They can be tanned with any material which is used in the tanning of sheepskins. Sumac is in common use; quebracho extract and quermos and hemlock extracts also make good skiver stock. If soft white skins are wanted, alum is used. Little tanning is required. It is generally sufficient to get the stock well struck through with the tanning material.

A good tannage is a mixture of two-thirds quebracho and one-third hemlock extracts. This produces a light and uniform color.

Coloring and finishing are the same as for skins; but skivers, being very thin, require careful handling to prevent them from getting torn.

**Roller leather.**—This leather is made from lambskins tanned with bark. The qualities needed are level substance, clear and perfect grain which has no scratches, scars nor cuts, smooth feel and pliability, with a certain degree of firmness. Only the best skins should be selected. The leather must be perfectly smooth on the grain, or the cotton thread used by cotton spinners—who use this class of leather—when it is drawn between the rolls, one of which is covered with leather, will keep breaking. As a light color is essential, only clean, light-colored bark liquors can be used. The natural grease contained in the skins must be removed since the edges of the leather covering the rolls are cemented together before being slipped over the roll, and if there is grease in the leather the cement will not hold.

The preliminary tanning is done in weak bark liquor. The skins are then subjected to hydraulic pressure in layers between iron plates, and are sprinkled with sawdust to remove the grease. They are then taken apart and paddled in a weak liquor, and drummed in warm salt water until all press creases have disappeared.

The skins are tanned by being suspended in the liquor, as a smoother grain is produced in this manner than when a paddle or a vat is used. The liquor consists of oak bark

extract of increasing strength, in which the skins remain 2 or 3 weeks, when they are hung up and dried. When dry, they are stored away until they are to be finished. The longer the skins are kept in the dry condition the better they are when finished.

When the leather is to be finished, the skins are sorted. Those that are not as perfect as they should be are finished into fancy leather. The roller skins are then dampened and shaved. The shaving must be accurate so that the skins shall be of even substance; however, the skins do not all have to be reduced to the same thickness, as some of the roller manufacturers make three or four different substances. After shaving, the skins are drummed in sumac solution and then

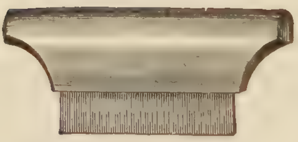

Figure 64.—Slicker and handle.

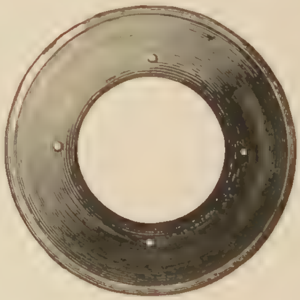

Figure 65.—Moon-knife.

go back to the tan to receive a stronger liquor. After being rinsed in water and drained, the skins are struck out on the flesh with a slicker (figure 64), and tacked out to dry. When dry, they are taken off the boards and softened, then trimmed and seasoned with milk and albumen, dried and rolled, perched by hand with the moon-knife (figure 65), and next re-seasoned and glazed. The finished skins are then marked with a frame on the flesh side and trimmed with a pair of shears. As every hair must be removed, the skins are wiped over with a cotton-wool pad to find the remaining hairs, which are removed very carefully so as not to break the grain. The skins are then ironed, and sorted into grades and sizes. The proc-

esses, of course, are not always followed exactly as outlined, but are modified as found desirable.

Oak bark makes better roller leather than hemlock, since it contains less filling matter and produces lighter-colored skins.

**Calfskin leather:** *Quebracho tannage.*—Calfskins for upper and fancy leather are tanned in numerous ways, and quebracho extract in solid or liquid form is in common use, producing a soft, tough leather.

A practical way to tan calfskins with quebracho extract is carried out as follows: A quantity of the extract is dissolved in boiling water. Solid extract should be dissolved in a tub containing a false screen bottom which prevents the extract adhering to a solid surface. Liquid extract should be dissolved in water at 180° F. The solution of extract should be stirred well and allowed to cool gradually before using. It is a mistake to chill the extract solution suddenly by running it into cold liquor. The tannage should be started in a weak liquor. Having the liquor too strong, and thereby drawing the grain, must be guarded against during the entire process. The suspension method, by which the skins are not violently agitated, produces the plumpest and best tanned leather, especially along the sides and in the flanks. The skins are tacked to wooden strips with galvanized iron or copper nails, and hung in the liquor.

The first tanning liquor is usually weak, not exceeding 10° bk. Where pickled skins are being tanned, salt should be added to the tan liquor, to prevent the acid in the skins doing injury. As the tanning proceeds, the strength of the liquor is increased until it reaches 20 to 25° bk. towards the end of the process. The period required to accomplish the tanning depends upon the thickness of the skins, and the strength of the liquor. It is always advisable to tan slowly, and so get a fine, smooth grain. When the tanning is completed, the leather is washed, pressed, and fat-liquored. From 7 to 14 days is usually required.

Another method employs a liquor made of quebracho ex-

tract, alum, and salt for the first part of the process, and a clear quebracho liquor for the second part. Prepare a liquor by adding enough dissolved extract to water in a paddle to make a 40 or 50° bk. liquor, and add 1 lb. of alum and 3 lb. of salt dissolved in hot water for every 100 gallons of liquor. Plunge the liquor well and throw the skins in. Start the wheel and turn the skins in the liquor for 36 hours or longer, which strikes them a light oak color; then place them in the second liquor, which should consist of clear quebracho liquor. Add enough dissolved extract to the water in the paddle to make a 6° bk. liquor. Turn the skins 36 hours; then strengthen the liquor to 10° bk., and continue the turning for 2 days, or as long as is necessary to complete the tanning. A mixture of quebracho extract and hemlock extract may be used in the same manner, also a mixture of hemlock and oak extract.

When thoroughly tanned, the skins are horsed-up and allowed to drain several hours or over night, and are then placed in sumac liquor. This is prepared by adding water at 122° F. to about 25 lb. of sumac, using the liquor at 90° F. The skins are thrown in and stirred more or less, and left in over night, then drained, set out, and either fat-liquored and dried, or dried without fat-liquoring.

*Gambier tannage.*—Calfskins can be made into fine, soft leather by tanning with gambier. The skins, having been limed and drenched, are put into a gambier and sumac liquor of about 10° bk. The liquor should be slightly acid to prevent thin leather, acetic acid being used to acidify it. After the skins have been in this liquor from 6 to 10 hours, they are placed in another liquor in a paddle, made up with gambier to a strength of 20° bk., 1 quart of acetic acid being added for each 5 dozen skins. The skins remain 10 hours in this liquor.

The third liquor should be made to a strength of 35° bk., and the same quantity of acid added as before. It is also beneficial to the quality of the leather to add, after the skins have been in it an hour, a pail of oak-wood extract.

When the tannage is completed, the leather is put into a

sumac liquor for several hours or over night, then drained, set out, and either fat-liquored, or dried without being fat-liquored. The sumac gives a good bottom for the subsequent dyeing.

A gambier process different from the foregoing method is applied in the following manner: The skins, bated and washed, are run in an old 12° bk. liquor until they are colored; and are then put into fresh gambier liquor, being hung therein for 12 days, during which time the liquor is gradually strengthened every day. The skins are then pressed and shaved, or split as they may require. They are next run in a 12° bk. liquor for a day or two before they are placed in a 34° bk. fresh gambier liquor for 16 days more. Salt should be added to the liquors to aid the tanning and keep the liquors from getting sour. Light skins, of course, require less tanning than heavy ones, the process described being suitable for heavy kangaroo skins and calfskins.

The tanned leather is washed, set out on a machine, oiled or fat-liquored, and dried at a moderate temperature. When dry, the leather improves in texture by being kept in the crust some time before it is finished. It can also be passed through a sumac liquor after the gambier tannage is completed. Drumming in a solution of alum and salt clears the grain.

A good method of tanning is accomplished in vats or tubs with paddles. In the first vat the skins are colored and handled; in the second liquor they are tanned until they are ready to be skived or split; and in the third liquor they are tanned out after skiving. At the start, the liquor should be 4 or 5° bk., and gradually strengthened as the tanning proceeds, until the skins are fully tanned. Into the water in the vats should be put 6 or 7 pails of gambier liquor standing at 75° Bé. in the pails or stock solution, also 4 or 5 pails of sediment gambier after the boiling. When the liquor is ready, put the skins in and run the paddle 30 or 40 minutes to ensure good color on the grain. The liquor should be strengthened twice daily—morning and evening—with 2 or 3 pails of

gambier and sediment, and the paddle run 3 times daily, 10 or 15 minutes each time. At the end of 4 or 5 days the skins should be taken out of the liquor and struck out on the flesh, and then put into the second or stronger liquor. By running the paddle 3 times each day, and by adding 3 pails of 75° Bé. gambier liquor each day, the skins become well struck through in about 14 days. Then set them out on the flesh side, skive them, and put them into the finishing liquors of 12 to 15° bk. for 7 days. Each day the liquor should be strengthened with 2 pails of gambier, and the wheel run 15 minutes each time: one pail of salt should be added to the liquor each week. The final tanning can also be done in a drum.

After the leather is fully tanned it should be cleared by drumming with alum and salt, oiled, and dried. It is then dampened, run in warm water and shaved, after which it is fat-liquored, set out, dried again, dampened, and colored.

Another way to treat the skins is to wash them after tanning, then fat-liquor and dry, shave, and mill in sumac, and then color. Good leather is also made by giving a light fat-liquoring after tanning and washing, drying the skins, coloring, and then giving them the second application of fat-liquor.

*Dongola tannage.*—Gambier, alum, and salt make what is known as dongola leather. There are many modifications of this process. Fine leather is made by tanning the skins first in gambier or quebracho liquor, and then giving them an alum and salt re-tannage. For 200 average skins, a mixture is prepared of 5 lb. of alum, 9 lb. of salt, 24 lb. of flour, 10 lb. of egg-yolks, or a corresponding quantity of sulphonated oil, and 8 to 10 gallons of water. The flour is made into paste with cold water. The alum and salt are dissolved in part of the water, and the flour paste is slowly stirred into the solution. The oil or the egg-yolk mixed with warm water is next added, and the whole mixture thoroughly stirred. The tanned skins are drummed with this mixture one hour, then dried, colored and finished, thus making soft, durable leather.

This mixture may also be used on untanned skins as they

come from the bate or drench. They should be drummed with it, dried, kept in crust some time, then wet-back and tanned with chrome liquor, the result being soft, durable leather.

The combination tannage of gambier, alum, and salt can also be applied in the following manner: The bated and washed skins are placed in gambier liquor in a paddle. From 3 to 5 lb. of gambier are used for one dozen skins. After they have started to absorb the gambier, from 8 to 16 oz. of alum and 8 oz. of salt are added to the liquor, for each dozen skins, and the paddling is continued until the tannage is completed, which takes from 18 to 36 hours. The leather is then washed in warm water to remove the adhering tan, next fat-liquored with acid fat-liquor, dried, wet-back, colored, dried again, and finished. After the alum and salt have been added it is customary to put the skins, together with the tanning liquor, into a drum and run them for a few hours or until thoroughly tanned. Some soluble oil may also be added to the liquor and applied to the leather toward the end of the tanning process. Excellent leather is also made by taking the skins out of the gambier liquor when they are well struck through, striking them out and then drumming them with a paste of water, flour, alum, salt, and either egg-yolk or soluble oil, drying, and then coloring them with a basic dye and titanium-potassium oxalate.

The color of the leather can be modified by adding a solution of fustic or other dyewood to the gambier liquor, and the entire process may be reversed. The skins may be first drummed with alum and salt and then tanned with gambier. Heavy skins may be tanned with gambier, split and shaved, and then re-tanned with gambier, alum, and salt. After the leather is dry, it can be colored with acid or basic dyes; and, if not fat-liquored immediately after tanning, drummed with acid fat-liquor or with an emulsion of oil and soap, staked and finished.

**Velvet and suede leathers.**—These leathers are produced from almost all kinds of skins, and there are various ways

of making them. The skins intended for this purpose are worked through the beam-house and tanned expressly for this finish, but how to get such leather out of a skin which was tanned in bark or some other vegetable tannage is an entirely different matter. The skins are sorted, and those which have poor grain and other imperfections are thrown aside. When there is enough to make a batch of 10 or 20 dozen, they are washed out with warm water and cleansed. The surplus water is then struck out, and they are snuffed on the wet wheel. After this has been done, they are re-tanned in a light solution of sumac, which also acts as a mordant for the coloring. The skins may be colored in a tray or wheel after which they are fat-liquored and dried. They can be washed out, re-tanned, then snuffed, colored, and fat-liquored, dried, staked, and ironed. Care must be taken that the iron is not too hot or it will scorch the nap and make it shiny. If rolled instead, the skins should be rolled on the unfinished side which is simply to flatten them out.

Another way is to emery the skins dry first on regular buffing wheels. Then they are treated as suggested above; but these skins never have such a close nap as those that are wet-wheeled.

When velvet or suede leather is to be made from sumac or extract-tanned skins, the goods are fluffed on the flesh side, and the grain receives a thorough grounding or buffing on a buffing wheel. Another method is to stake them lightly and then to buff lightly on a buffing machine. At the beginning of the dyeing operations the skins are run in the paddle or drum for 15 minutes in lukewarm water; they are next treated in a weak acid bath—0.25 per cent or less of sulphuric acid—and run in this for 20 minutes to clear them. The leather is rinsed and given a light re-tannage of 1 to 1½ per cent of sumac extract in the drum, and is then colored.

**Russia calf.**—As the skins come from the bate they should be in a very open and flaccid condition. They are tacked on sticks and suspended in the gambier liquor vats. This liquor is made from matt gambier to which, for each 300 lb. about

50 lb. of liquid chestnut-oak bark extract is added. The strength of this liquor should be about 35° bk., so that it may be used to strengthen the liquor in the vats or diluted for new liquor. The first liquor should stand at 18° bk., and should gradually be strengthened so that at the end of 3 days it should still stand at 18° bk. At the end of this time the skins are removed from the sticks and thrown into the first handler liquor. Each day thereafter they are passed forward through a series of stronger liquors until tanned. Calfskins usually require 6 days in the handlers, whereas kips or heavy calf require 8 liquors. The barkometer of the first handler should be about 20°, while each succeeding liquor should be slightly stronger until the final handler, which should stand at 30°. When the skins are removed from the last handler they are given a slight washing, pressed, and shaved, and are then returned to the yard for bleaching and re-tanning.

*Bleaching.*—Either 300 calf or 150 kips are placed in the drum and washed for 10 minutes with running water. Twenty-five gallons of water containing 5 lb. of borax is now introduced, the drum run for 15 minutes and the skins again washed in running water for 20 minutes. Add 25 gallons of water containing 35 oz. of concentrated sulphuric acid to the skins in the drum, and run for 30 minutes. The stock is finally rinsed for 20 minutes in running water, and horsed-up to dry.

*Re-tanning with quebracho.*—Make up a fresh quebracho liquor standing 8° bk. and introduce the stock—600 calf or 300 kips constituting a pack—run the wheel at half-hour intervals during the day, gradually raising the strength until it reaches 12° bk. The time of treatment should be 4 days for skins and about 6 days for kips.

*Drumming with sumac.*—After the skins are pulled from the paddle they are divided into 3 packs. Each pack is washed with running water for 5 minutes and excess of water allowed to drain off. Then half fill a barrel with water, add 32 lb. of sumac, boil, cool, and make up to 50 gallons with water. Mix well, and filter 25 gallons through gunny cloth

into a clean barrel. Make up the filtered liquor to 50 gallons, add this to the contents of the drum, run 30 minutes, wash, and fat-liquor. The fat-liquor should consist of a mixture of moellon degras, neat's foot oil and soap. They are then hung up to dry, given a second fat-liquoring and again dried.

**Vegetable-tanned kangaroo leather:** *Quebracho extract tannage.*—In the tanning of vegetable-tanned kangaroo leather, quebracho extract is used, also a combination of this substance with gambier is sometimes employed. When quebracho extract is used, the required quantity is diluted with water in a barrel to form a stock solution from which the tan liquor is made and strengthened. The first tanning liquor is rather weak, about 8° bk. The pickled skins are suspended in this liquor, which should contain some salt, and as the tanning progresses the strength of the liquor is increased until it is about 20°. The time required for tanning depends upon the thickness of the skins and the strength of the liquor, and ranges from 3 or 4 days to 2 weeks. Salt should be present in the liquor to prevent excessive plumpness of the fibers.

A tannage with quebracho extract, salt and alum produces full, well-tanned leather. To every 100 gallons of quebracho liquor of 4° bk. strength add, while the liquor is warm, 2 lb. of alum and 4 lb. of salt, and plunge the liquor well. At the end of 36 hours the skins are ready for the second liquor. Heavy skins may remain in the first liquor for 48 hours. The second liquor consists of quebracho of 6° strength, gradually strengthened until the skins are tanned throughout. When taken from the liquor, the leather is rinsed in warm water, fat-liquored and dried, then moistened, shaved, colored, and finished.

When quebracho and hemlock extracts are combined, the proportions should be 66 per cent of the former and 33 per cent of the latter. The tannage is begun in weak liquor, which is strengthened as tanning proceeds until the goods are tanned throughout. When the leather is taken out of the liquor it is improved by drumming in a sumac liquor for an hour or two before drying it out.

*Gambier and sumac tannage.*—Kangaroo skins may be

struck through by being run in a paddle in gambier and sumac liquors of 10° bk. strength. There should be sufficient acidity in this liquor to keep the skins plump, they being tanned after bating and washing, without pickling. It is better to add a quart of acetic acid for 50 skins. After running in this liquor for a few hours, the skins are passed into a gambier liquor of 20° bk., to which acetic acid has been added. Formic acid or butyric acid could be used with equally good results.

The skins remain about 12 hours in this second liquor. The third liquor should be made up to a strength of 35° bk., and the same proportion of acid added. A small quantity of oak-wood extract added helps to make well-filled-out leather. When well struck through the skins are ready for the sumac bath. This is prepared in a paddle-wheel by adding water at 125° F. to 25 lb. of best sumac and cooling down the bath to 90° F. before putting in the goods.

After lying in the sumac liquor over night the skins should be horsed-up and drained, fat-liquored, and dried; and when thoroughly dry, they may be dampened, shaved, and dyed black. The leather should be soft and well tanned. Good leather is also made by tanning the goods in a liquor made up of 6 lb. of gambier, 2 lb. of salt, 1½ lb. of alum, 1 lb. of sodium sulphate, and ½ oz. of picric acid for a dozen light skins. Boil the gambier separately, as well as the other ingredients, and then mix the two solutions. The tanning liquor can be given to the skins in a drum, 1 gallon at a time, and drumming continued until the goods are tanned throughout. The skins need not be pickled, but are tanned after bating and drenching. Hanging them in the liquor is also a good way to tan them. After being fully tanned, the leather should be drained, rinsed, pressed, and treated with acid fat-liquor, then dried, moistened, dyed, and finished.

*Other tannages.*—Sometimes skins which have been tanned with gambier or with quebracho are re-tanned with alum, salt, and soda, then fat-liquored and dried. The entire tanning process can be carried out in a drum. This produces a soft dongola leather.

Another form of dongola tannage consists of tanning the skins first with gambier, then giving them a sort of kid tannage in a drum; 100 medium skins, pressed from the tan, being given 2 lb. of alum, 5 lb. of salt, 12 lb. of flour, 5 lb. of egg-yolk, ½ pint of olive oil, and 6 gallons of water. The alum and salt are dissolved in 2 gallons of water and the flour is next carefully stirred in. The other ingredients are then mixed with warm water and thoroughly stirred in. The skins are drummed with the mixture until they have absorbed it, when they are rinsed off, struck out, and dried.

A combination of gambier, flour, and sulphonated oil, thoroughly mixed and made into a sort of paste, also makes excellent leather. No subsequent fat-liquoring is necessary. One hundred medium skins free from acid require 50 lb. of gambier, 6 lb. of salt, 2 lb. of alum, 12 lb. of flour, 3 or 4 lb. of oil, and 6 gallons of water. The gambier is boiled and cooled and the other ingredients are added. When dry, the skins are dampened, shaved, dyed, dried again, staked, and finished.

**Vegetable-tanned side leather.**—In the manufacture of leather of various kinds from hides and kips which are finished on the grain side, various processes of tanning are employed. Hemlock bark and hemlock extract are used; also gambier, chestnut and quebracho extracts, and other extracts and tannin-yielding materials. Quebracho extract is largely used alone, but it is also combined with hemlock and chestnut extracts. Hides are also not infrequently started in quebracho liquor and re-tanned with some combination of extracts. Gambier is one of the staple tanning materials. It makes soft and tough leather which is readily colored and finished in any desired manner. The tanning with gambier and extracts is usually done in vats that are provided with paddles by which the liquor is stirred; pits or vats in which the hides are suspended are also used. The less agitation and pounding hides are subjected to during tanning the fuller and plumper the finished leather will be, especially in the flanks and along the sides. A common method of tanning consists of treating the hides with hemlock bark liquor until they are struck through,

then splitting them and re-tanning the grains with gambier and sumac.

*Tanning with hemlock and quebracho extracts.*—One of the best combinations of extracts which a tanner can use is a mixture of quebracho extract and hemlock liquors. Hemlock is a rather harsh tannage when used alone, and quebracho is therefore frequently used with it, the result being soft, pliable leather of good color. Quebracho also hastens the tanning and reduces the cost.

The hides are limed, bated and washed, and are then subjected to tan liquors, consisting of about two-thirds quebracho to one-third hemlock. This tannage can be used for tanning almost all varieties of leather.

The color is fair and uniform, and the reduction of time consumed by the process is about a third of that required where bark liquors and "layaways" are used. The leather is readily colored with little or no bleaching. When hemlock bark is not obtainable, extract can be used in place of the bark liquor. The sides are first suspended in a weak coloring liquor for about 24 hours. They are then taken out and placed in a liquor of a strength of 10° bk. As the tanning progresses, the liquor is strengthened each day until it is about 30°. The tanning should not be hurried by using strong liquor, as this makes harsher and less desirable leather than a slower tannage in weak liquor. When the sides have become well struck through with the tan, which takes about 20 days, they are pressed and split. The grains are then re-tanned with hemlock and quebracho liquor, or with gambier and sumac. A small proportion of sulphonated oil may be added to the retanning liquor with benefit to the leather.

*Tanning with quebracho extract.*—This extract is used at present by tanners of sheepskins as well as by those of sole, upper, and other heavy leathers. On sides, quebracho extract is an admirable substitute for the higher-priced gambier, producing fine grain, soft texture, and firm feel. On patent leather it gives a pliability which prevents cracking after the varnish is put on.

The extract made from the wood of the quebracho tree is different from all other known tanning extracts, as it will not turn sour. In addition to this, it is a comparatively clean extract, that is to say, it contains a higher percentage of tan to a given density than any other of the well-known extracts. Inasmuch as it has little or no tendency to ferment, quebracho is extremely useful for controlling the acids in tan yards, which tend to go sour.

Quebracho extract, therefore, is not itself a plumper, and if it is used on leather which has not been properly plumped, is likely to tan the outside of the hides quickly and thereby prevent the penetration of the tan to the inside, the result being cracky leather not properly filled. If, however, hides are plumped before they are placed in quebracho liquor, this material will penetrate, fill, and produce tough, pliable stock of light color.

An important point to be observed in using quebracho extract is that it must be thoroughly dissolved. Solid extract should be boiled in a tub containing a false screen bottom, which prevents its adhering to a solid surface. The liquid extract should be dissolved in water at 180° F. The resulting solutions from both grades of extract should then be stirred well and allowed to cool down gradually before being used. It is a great mistake to run hot quebracho liquor into cold vat liquors, or in fact to chill any extract liquor suddenly. The sediment that remains in the cooling tub may be worked up with fresh water on a tail leach or elsewhere. A great deal of the successful use of quebracho in the vats depends upon the proper method of dissolving it, and it is much better that such precipitation as takes place should go on in the cooling tub rather than on the leather.

*Tanning with gambier, sumac, and oak extract.*—Where a soft well-tanned leather is required, which can be colored any shade or dyed black, a tannage with gambier, sumac and oak extract may be used with satisfactory results. The hides should preferably be split out of the lime and the grains then bated and washed. A liquor composed of gambier and sumac

of about 10° bk. is prepared in a paddle. After the grains have been in this liquor for 5 or 6 hours, they are put into a gambier liquor of 20°, to which a quart of acetic acid for 40 small grains has been added. Tanning may be accomplished by suspending the goods in the liquor, by using a paddle or by drumming after the grains have been well struck with the tan.

The third liquor should be made up to a strength of 35° bk., and the same proportion of acid added. After the grains have been in this liquor for 3 hours, a few pails of oak-wood extract should be dissolved and added. The tanning should continue until the goods are tanned throughout. When this has been accomplished, the leather is drained and then treated with sumac in a drum or a paddle.

A sumac liquor is made up in a paddle by using 25 lb. of best sumac in water heated to 125° F., the liquor being cooled down to 90° F. before the skins are put in. The leather may be turned in this liquor several times and left in over night, or drummed with it two hours; it is then drained, rinsed off and dried or fat-liquored, dried, colored, dried again and finished.

Equally good results may be obtained by using quebracho extract in place of gambier. In the last stages of tanning, if a drum is used, some sulphonated oil may be added to the liquor. This helps in getting leather dried soft and pliable, and reduces the amount of fat-liquor to be given later on. The sumac for one dozen sides may be made from 2 pails of sumac scalded in 20 gallons of water, and used at 90° F. The leather may be drummed in the liquor 2 hours, piled down 24 hours, drummed again 2 hours, rinsed off, and dried.

*Tanning with gambier.*—The sides are started in weak liquor, which is gradually strengthened by the addition of fresh gambier until it becomes fairly strong towards the end of the process. Common salt serves a useful purpose in gambier tanning, as it assists in making soft leather, in hastening the tannage, and preventing contraction of the leather fibers. Acetic acid also should be added to gambier liquor

to prevent thin, papery leather. It is well for the tanner to divide his tanning liquors into three portions: In the first the hides are colored; in the second the tanning goes forward until the leather is ready for splitting; and in the third the re-tanning after splitting is accomplished. At the beginning

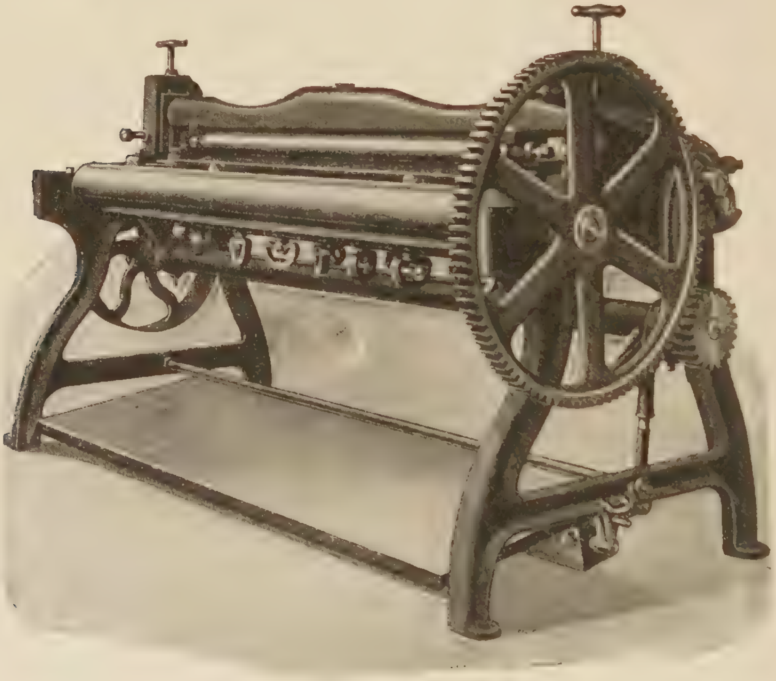

Figure 66.—Union splitter. Formerly much used for furniture and automobile leather, but now replaced by band-knife machine.

the liquor may be 4 or 5° bk. It should be strengthened twice each day, the quantity of fresh liquor added depending upon the size of the vats and the strength of the liquor at the start. No exact rule can be laid down, as the individual tanner must decide this and other problems. The tanning should always go steadily forward until the hides are tanned throughout, when the leather should be split, re-tanned, and fat-liquored.

*Combination process.*—A tanning process in which hemlock, chestnut wood, and quebracho extracts are used for

tanning, and quebracho and gambier for re-tanning, is carried out in the following manner: The hides are hung on sticks in a 7° bk. hemlock liquor, and are handled each day for 3 days, the liquor being strengthened up to 10°, and finally up to 12°. After having been in the 12° liquor 24 hours, the sides are passed into a 16° combination liquor, made of chestnut-wood extract and quebracho extract. This liquor is gradually raised to 20°, the process requiring from 14 to 16 days. The sides are then pressed, split, and tanned. The re-tanning liquor is made of quebracho extract and gambier, 3 parts of the former and 1 part of the latter; and the strength 26° bk. The grains are drummed an hour in this liquor, then left in piles 24 hours; drummed again for an hour; piled down for 24 hours; then washed and finished. This is a good tannage for many varieties of leather, shoe upper, bag, case, etc. As described, it is most suitable for large, heavy hides.

*Pressing and splitting.*—Before leather is split it is pressed to rid it of surplus liquor and to put it into good condition for splitting, which may be done on the union splitter (figure 66) or on the belt-knife machine. Considerable moisture should, however, be left in it. When pressed too dry, the leather must be milled with weak liquor to prepare it for the strong re-tan liquor, and this milling pounds the grain and makes it loose and "pipey."

When there is considerable moisture in the grains they do not need to be milled in weak liquor, but can be put at once into the re-tan liquor. The more moisture there is in the grains the better the results.

**Re-tanning with gambier and sumac.**—Leather that has been tanned in hemlock liquors, no matter what the finish may be, is much improved by being re-tanned with gambier and sumac. Re-tanned in this way, the flanks are made fuller and firmer, the fibers are slightly contracted, the harsh effect of the hemlock is toned down, the leather is given a smooth feel, and the color is less liable to fade. The leather is tanned with hemlock and then split.

The re-tanning is effected in a drum, being thus accom-

plished in less time than in a vat. A good re-tanning liquor for harness and other kinds of leather is prepared in the following manner: Boil 250 lb. of gambier in 80 gallons of water; and when the solution is fairly cool, skim off all foreign matter. Ten gallons of this liquor is sufficient for 30 average sides. This quantity is put into the drum, together with the leather, and 2 gallons of dry sumac are added and as much water as needed to make the leather wet without dripping. Run the leather in this liquor at least 30 minutes. The sides should then be packed in boxes by doubling the flesh side outward, and left in that condition for 10 or 12 hours.

They should next be scoured or washed, and treated in the usual way of coloring, fat-liquoring, etc., according to the kind of leather and the finish desired. Gambier and sumac used as described improve the leather greatly, and the expense of their use is repaid by the improved quality. Bark-tanned and extract-tanned leather may be re-tanned with gambier and sumac in the following manner: Two pails of Sicilian sumac are boiled 15 minutes in 40 gallons of water, and the resulting liquor is allowed to stand over night. On the next day, 12½ lb. of gambier is boiled until dissolved, and this solution, together with 10 lb. of salt, is added to the sumac liquor. There should be 50 gallons of the liquor, and it should be used at 80° F. The leather is run in it one hour, then left in piles 24 hours, rinsed off, and fat-liquored. Before being re-tanned, the leather, after it has been split and shaved, should be washed for a half-hour in warm water containing 3 lb. of potassium carbonate in 50 gallons of water. It is next drained and washed, and then re-tanned.

*Re-tanning grains with sumac.*—Hemlock-tanned and combination-tanned leather, after it has been split into grains and splits, is benefited by a re-tannage with sumac. The sides are taken out of the last tan liquor and allowed to lie in a pile 48 hours. They are then pressed or put through a wringer to force out the surplus liquor. Some tanners run their leather through a splitting machine with a corrugated gauge roll,

which makes pressing unnecessary. Leather that has been pressed usually shows some marks, and to remove these it is jacked on a stoning-jack (figure 67).

Splitting is the next operation, and the grains are then re-

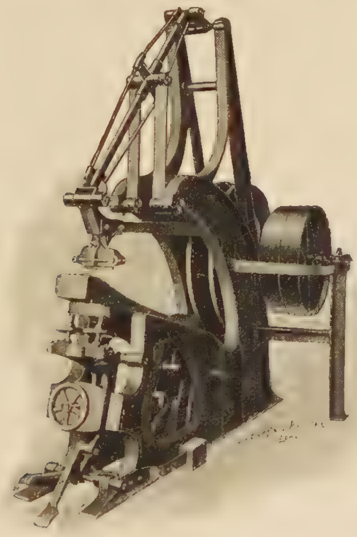

**Figure 67.—Iron frame stoning-jack.**

tanned with sumac in a drum. This re-tanning is very beneficial to the leather, making it of finer texture and color, also rendering it capable of taking better and more uniform coloring.

The sumac liquor is prepared by scalding 2 pails of sumac with 20 gallons of water heated to 125° F., and allowing it to steep some time before using it. When the liquor is cool it is ready for use, this quantity being sufficient for one dozen medium sides. The leather is drummed an hour in this liquor. It is then placed in smooth piles for 24 hours, when it is drummed again with sumac liquor the same as before, then again piled down for 24 hours. The next operation is dipping the leather in warm water to wash off the sumac, and then scouring or setting it out and finishing it according to the finish desired. It can be dried and then fat-liquored later.

The splits for flexibles or Goodyears are trimmed and put into a drum, together with tan liquor of 6° bk. strength, and drummed one hour, which opens them so that they will take the re-tanning liquor. Re-tanning can be done in a drum in about 6 days, the splits being drummed in a strong liquor 2 hours each day and left in piles the remainder of the time. This operation is repeated daily for 6 days, when the splits will be fully tanned and in better condition than when they are drummed continuously.

Gambier, hemlock extract, and alum make a good re-tannage for hemlock-tanned leather. The proportions of gambier and hemlock should be equal parts of each, the strength being 25° bk. Twenty-five sides should be given 4 pails of the liquor and 4 lb. of alum dissolved in 2 gallons of water. The leather is run with this liquor for an hour, then piled down over night and hung up the next morning to dry. When dry, it is fat-liquored, colored, and finished.

A combination of 75 per cent of quebracho and 25 per cent of gambier is recommended for re-tanning grains for upper leather. One pint of sodium bisulphite added to each 3 gallons of re-tanning liquor causes the liquor to penetrate more quickly into the leather. The strength of the quebracho-gambier liquor should be from 24 to 28° barkometer.

Any of the foregoing processes may be used in the re-tanning of leather for colored and black upper stock, dull or bright grains, and imitation kangaroo; also for bag and case leathers.

**Tanning sealskins.**—Raw sealskins come to the tanner in a freshly salted condition, and are, broadly speaking, divided into two classes: "small" or "white-coat seal" and "large" or "cow seal."

The former seals are principally used for making levant grain leather, and the latter for walrus grain, though a grain similar to the latter is frequently produced on the small seal and likewise the levant grain on cow seals. As the processes differ somewhat in obtaining the different grains, it is necessary to describe them separately.

*Levant grain.*—The skins, when received by the tanner, are covered with salt and are very greasy. A convenient pack of about 25 dozen is placed in the soak pits. The water in the pits should not be too cold, and during the winter therefore it is necessary to warm it a little.

After remaining in soak for a day, the pack is hauled-up and fleshed over a beam. As much of the loose blubber and grease as possible is removed by the beamster. The skins are then put into a fresh soak and remain in it 48 hours, when they are again scraped over the beam, this time on both flesh and hair sides. It will be found, owing to the greasy nature of seals, that the beamsters have difficulty in handling their knives, but this is readily overcome by occasionally rubbing their hands with sawdust.

The skins are now ready for liming. White lime alone should be used, as it has been found to produce the best results. Sodium sulphide and lime produces pipey grain, but arsenic and lime yields a soft and silky grain.

The time required for liming varies according to the weather, in winter 21 days being needed, while in summer not more than 16 days are required. The extremely greasy nature of the skins make it necessary to give them this long liming. To produce a firm leather with the requisite hard grain it is necessary to keep the limes as fresh as possible; old and stale limes make leather which is tender and has a soft grain.

The skins are unhaired on the beam; care being taken to rid them of the young hair, which is sometimes difficult. After unhairing, the superfluous lime is removed by washing in a wheel. When the water running off is quite clear the skins are ready for puering or bating.

Good results are obtained with Dennis "puerine," or with oropon. The skins should be brought down fairly low, and a good guide to determine when they are low enough is to take one out occasionally and pinch it between the forefinger and thumb. The process has gone far enough when a decided impression is left on the grain. From 2 to 6 hours

should bring them down, though large skins require longer treatment. The skins are next scudded over a beam, slate knives being usually used for this, which is an important operation as it removes any free lime or lime salts in the skins.

After scudding, the skins should be thrown into a bran drench and left in for 5 or 6 hours. They are then rinsed in warm water and tanned.

Quebracho extract and sumac are employed for tanning the skins. A cube of solid quebracho extract is dissolved in a barrel of boiling water. This constitutes a stock solution. A 10° bk. solution of this extract is taken and drummed, together with the skins, in a closed wheel for an hour, sufficient liquor being used to cover the goods. This sets the grain. The skins are then put into a paddle containing about a 12° liquor, and remain in it until they are tanned, the strength of the liquor being gradually increased. Tanning should be completed in a week, which can be tested by cutting off a small piece and observing whether the tan liquor has entirely penetrated the middle of the skin, leaving no white streak. When tanned, the skins are drummed for 2 or 3 hours with a liquor made of a half bag of sumac and a few pails of liquor. They are then struck out on a machine and hung up to dry. When quite dry, they are taken down and struck out either by hand or by machine, using hot water to soak them in; then they are hung up for part drying. Such edges as dry out should be re-dampened with a sponge before re-setting the skins on a table. After this re-setting, the skins are ready for blacking.

*Walrus grain seal.*—The large sealskins generally used for this kind of work are soaked in the manner already described. In liming them, however, a pound or two, according to the size of the pack, of sodium sulphide is used with lime. From 10 to 16 days is enough liming for this class of work.

When unhaired, the skins are washed in water and bated; then taken out and drummed in warm and fairly strong liquor, which contracts the grain, thus forming the well-known walrus grain. The subsequent tanning is effected in a paddle, and

when tanned, the skins are hung up, dried, blackened, grained, and seasoned.

Heavy skins are split out of the lime on a belt-knife machine. The substance of the grains and splits varies according to the requirements of the market. The grains are finished into patent or enameled leather, and also for bookbindings and fancy leather goods. Two thin middle splits and one rough split can, as a rule, be made from each skin; and the "linings" are then usually thrown back into the limes for about two days, with one handling, to get rid of as much of the grease as possible. The linings are then washed in tepid water, slightly acidified with acetic acid to neutralize any hardness.

The split skins are bated, drenched, and slated out of warm water, and are then ready for tanning.

In addition to the process of tanning with quebracho and sumac, already described, sealskins may be made into good leather by tanning with gambier and sumac, the liquor at the beginning being about 10° bk. strength. Care must be taken to have plenty of acid, otherwise the skins will fall, and will be flat and papery when finished. After running in this weak liquor for about 6 hours, the skins are passed into a 20° liquor. It is well to add about a quart of acetic acid for every 5 dozen grains or linings. The goods remain in this liquor about 7 hours.

The third liquor should be made up to a strength of 35° bk., and about the same amount of acid mentioned above should be added. It will also help to fill out and improve the goods if a pail of oak-wood extract is added to the liquor after the skins have been running in it half an hour. If this has been properly carried out, the goods will be struck through, and should be horsed-up and allowed to drain ready for sumacking.

This is best done in a vat, although a paddle is sometimes used. This bath is prepared by adding water at about 125° F. to about 23 lb. of best Palermo sumac. Cool down to 86° F.; enter the goods and haul-up once or twice, warming

the liquor each time. After lying in the sumac over night the skins should be horsed-up, and, after draining, taken to the sheds for drying. Care should be taken not to expose them to strong or harsh winds in the early stages, and the use of steam and artificial heat should be avoided as much as possible.

*Tanning the splits.*—The splits may be tanned as follows: Put them in a mixture of best oak-wood extract and water at 35° bk., and for every 5 dozen splits add 2 quarts of acetic acid, which helps to maintain the goods in a plump condition. Keep the splits (linings) in this liquor for two days, handling once. Horse-up to drain and dry out steadily. Cube gambier costs more than block gambier, but it is richer in tannin and does not contain dross. The best Sicilian sumac should always be used.

*Directions for finishing.*—When the grains are brought down from the shed, they are treated, where weight is a consideration, as follows: For every 10 dozen take 28 lb. of barium chloride, and with sufficient water to wet them, work the goods in a drum, together with 6 gallons of sumac for an hour at 104° F. From this they are plunged, a dozen at a time, into a weak solution of sulphuric acid, which should be moderately acid. Stir the skins for 3 or 4 minutes until they assume a whitish appearance. The chemical action causes the barium chloride to be changed into barium sulphate. After each dozen skins is taken out of the bath, sufficient acid should be added to maintain the required acidity.

The skins are now ready for hoisting up and striking up, the latter being done on the grain side in the ordinary way, and the grain wiped over with best linseed oil. They are then hung up to stiffen sufficiently for setting. When ready, let them lie in piles, after damping down all dry parts, for a day or two, and then set out lengthwise and after that from neck to butt. Now hang them up and allow them to dry out. When dry, break down with the graining board (figure 68), pushing the goods upon the flesh side from neck to butt, and turning and doing the same on the grain side. Fluffing or buffing

follows. This should be effected on a fine emery wheel, and done crossways, commencing at the butt, going about half across, turning round and reversing; then drawing the skins straight down on the grain.

*Treatment for split linings.*—The linings, after being dried out, may be weighted by drawing them through a strong solution of barium chloride, as above described, but they must be drawn through the acid bath one at a time, if tearing is to be avoided. Now wash them with warm water and lightly strike out with a suitable ridging board. The splits are then ready

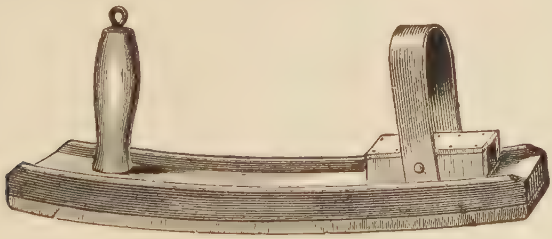

**Figure 68.—Cork arm-board.**

for staining, and, when dry, are buffed on one side and enameled on the other.

**Tanning pigskins.**—Pigskins usually come to the tanner in a pickled condition, and should be de-greased by running in lime or soda solution. They may be also very satisfactorily de-greased with the gargoyle compound, described in Chapter II.

Quebracho extract makes a satisfactory tannage for pigskins. Prepare a liquor by adding enough dissolved extract to 700 gallons of water in a paddle to make a 4° bk. liquor. To this liquor add 10 lb. of alum and 25 lb. of salt dissolved in hot water. Plunge the liquor until it is thoroughly mixed. Start the wheel, throw in the skins, and turn them 36 hours or longer, which strikes them a light oak color, and they may then be placed in the second bath, which should consist of clear quebracho liquor. Add enough dissolved extract to the water in the paddle to make a 6° liquor, omitting the alum and salt. Turn the skins 36 hours; then strengthen the liquor

to 10°, and leave the skins in the liquor for two days, which completes the tanning. The second liquor may also be given the skins in a drum. A mixture of quebracho and hemlock extracts may be used; also a mixture of hemlock and oak extracts.

When the skins are tanned, pass them into a sumac liquor in a paddle or vat. The liquor is prepared by adding water at 122° F. to 25 lb. of sumac. Cool down to 86° F. before entering the goods, and haul-up once or twice, warming the liquor each time. After being in the sumac liquor over night the skins are struck out and oiled on the grain with neat's foot oil or sulphonated oil, and hung up to dry or tacked on frames. When dry, they are staked and boarded, and are then ready for the finish. The leather can be bleached if a lighter color is wanted, or colored any shade, or dyed black.

Quebracho makes a fine, natural grain, free from spue, and firm, strong leather. For bag leather, hemlock extract is a good tannage; so is hemlock and quebracho. The skins are started in a weak liquor, which is strengthened twice a day, until they are struck through, which takes about 8 days. After tanning, they may be bleached and drummed in a sumac bath. Next wash them with clean water; slick them out; give them a little oil and hang them up to dry. After drying, dampen and shave the skins that need it and then apply fat-liquor.

*Tanning with sumac, oak bark, and alum.*—A soft, light-colored pigskin can be produced by tanning in the following manner: Pickle the skins with sulphuric acid and sodium chloride (salt); next remove the acid in a drench of whiting and salt, and then wash them in two baths of warm salt water. To make the tan liquor, dissolve 6 lb. of alum, 4 lb. of Glauber's salt, and 4 lb. of common salt in 6 gallons of water; in another tub boil 5 lb. of ground sumac, 3 lb. of oak bark, and 1 lb. of ground nutgalls in 5 gallons of water. Mix the two solutions; strain the mixture while it is hot, and add 4 oz. of sulphuric acid. The liquor should be used lukewarm, and the skins drummed in it for several hours, then allowed to drain 24 hours. Tanning can also be effected in a paddle.

After draining, the skins should be struck-out on both sides and oiled fairly heavily and dried. As they dry they should be staked, so that when the leather is dry it is soft and pliable. It can be easily colored any shade. It is quite waterproof and durable. Oak bark is an especially good tannage for pigskins; so is chestnut extract.

Another method of tanning with quebracho and sumac is carried out as follows: A cube of solid quebracho extract is dissolved in a barrel of boiling water, forming a stock solution. A 10° bk. solution of this extract is taken and drummed, together with the skins, in a closed drum for a half-hour or longer. This sets the grain. The skins are then put into a paddle containing a 12° liquor, and remain in it until they are tanned. The strength of the liquor is gradually increased. When tanned, the skins are drummed with sumac liquor for 2 or 3 hours; they are then struck-out on a machine and hung up to dry. For black leather the skins may be handled and blacked in the same manner as sealskins.

**Tanning snake skins.**—These skins should be soaked until soft, then limed to remove the scales; and after bating they may be tanned in bark or extract liquors like calfskins and sheepskins, beginning with weak liquor, handling often, and increasing the strength daily. While soaking, they should be worked by hand until they are soft and flexible and the outer scales have been removed; they are then in condition for tanning. Gambier, sumac, quebracho, chestnut extract, or a combination liquor may be used. The tanned skin is soft and flexible, and the natural colors are little changed.

A process of tanning with alum, salt, and gambier is carried out in the following manner: The skin is soaked in the usual way. It is then fleshed and put into lime for 4 or 5 days until the outer scales can be removed. It is then bran drenched and depleted, washed, and pickled for 2 days with salt and alum liquor of 1 part alum, 2 parts salt, and sufficient water to cover. Tanning is then started in a 5 per cent gambier liquor, which is strengthened daily until it reaches 10 per cent. The skins are tanned in a few days.

Quebracho extract or chestnut extract may be used in the same manner as gambier. After the tanning is completed, the skins are fat-liquored with sulphonated oil; dried, wet down, shaved, sumacked, oiled again if necessary, stretched out carefully, and dried. The flesh may be made clean and smooth with sandpaper or on an emery wheel. A bright finish is obtained with casein or shellac; a dull finish with flaxseed liquor or gum tragacanth.

**Fancy leather calfskins.**—Only the finest calfskins are selected for this class of leather, and they should, as far as possible, be free from butcher cuts and other imperfections. The weight of the skins for this line of manufacture usually runs from 4 to 7 pounds each. They are generally green-salted or are in a dry-salted condition, and must be soaked in water in the usual manner, and made soft and clean.

One hundred skins make a pack of convenient size. They are first run in a drum which permits a constant supply of water being run into it while revolving, and which has openings for the water to run out again. If the pack is green-salted, washing for one or two hours is sufficient; but dry-salted stock requires longer treatment. The main object is to get the skins soft without the loss of substance, and this can be greatly accelerated by having pegs inserted in the inner side of the drum. The skins are next fleshed and limed.

During the liming of this class of leather, the tanner must remember that a very soft-finished product is required, with a tight, smooth, and clear grain; therefore great care and judgment must be exercised at this stage, for, as most tanners know, the liming makes or mars the finished product. Local conditions must be considered, as well as the season of the year.

Lime and arsenic are the depilatories used. The arsenic is valuable, not only in hastening the loosening of the hair, but also for the softening effect it has upon the skins, rendering them supple and making the grain close and smooth. After remaining in this one or two days, they are hauled up and allowed to drain, preparatory to going into new lime.

After unhairing, the skins are well washed in running water until the surface lime is removed and then bated and delimed. This is done in one of the several bating processes which have been described for calfskins, the method of bating with oropon, or the process in which glucose, sulphur, and yeast are used, being especially suitable. The skins should be bated in such a manner that they are soft and clean, and have the fine grain that is desired. After having been bated they are scudded. This is done on a bolstered beam, using a slate knife, and is an important operation, as it removes much of the dirt and rids the skins of lime dissolved by the bate. Furthermore, all of the fine hair which may still be in the skins is removed. The skins are next drenched with boracic acid, formic acid, or any other suitable drenching material, and are then pickled.

Pickling for this class of leather is effected satisfactorily with formic acid and salt, which cleanses the skins and gives them a good grain. Pickling makes soft leather which has a clear grain and good color. Quebracho extract is commonly used for tanning skins for fancy leather. Some of this is dissolved by boiling in water in a barrel, thus forming a stock solution from which the tan liquors are made up and strengthened. The skins are held in suspension in the vats by tacking them to wooden strips, using galvanized iron or copper nails so as not to stain them. One nail on each butt shank is enough, two skins on each side of the strip, with the grain side out, being thus suspended.

The first liquor in which the skins are hung is weak, from 7 to 10° bk. As the tanning progresses its strength is increased, so that at the last it will be of 20 to 25°. The chief point to be considered is to avoid drawing the grain by using too strong liquors at first. Salt must always be present, especially when sulphuric acid is used as a pickle, to prevent injury from the acid. The time required for tanning varies according to the handling of the skins and the strength of liquors, but should be accomplished in 7 to 14 days.

When the tanning is completed, the skins should receive a

slight fat-liquoring. The grease should be entirely absorbed by the leather; the skins are then drained, slightly struck-out on the flesh side, or hung up at once and dried. When thoroughly dry they are sorted into various grades; those that are light in color, clear of grain, and free of imperfections being put into the lightest colors, while those with slightly imperfect grains are most suitable for black leather.

**Combined vegetable and mineral tannage.**—Each of these two methods of tanning possesses unique advantages, and it has been the aim of tanners to incorporate them into one method, but so far this has not met with much success. The chrome process gives, for example, suppleness and toughness to leather without fullness or weight, so that any skin that has been chrome-tanned must not be inclined to looseness of texture, as this fault would be accentuated in the finished leather. The vegetable tanning process, on the other hand, gives excellent weight and fullness, but lacks the characteristic suppleness and strength of chrome leather. When a combination of these two processes is tried by making one follow the other, it is usually found that the production of one good quality is accompanied by the presence of a corresponding bad quality. For example, if empty chrome-tanned leather is, for the sake of fullness and firmness, re-tanned in some vegetable tanning liquor, these two qualities will be produced, but the toughness of the leather will be sacrificed.

**Vegetable-tanned patent shoe tipping.**—The tanner who makes chrome leather from hides can realize greater profit from his poor-grained hides by working them into tipping stock than by allowing them to go through the works, and then to be sold as No. 3 chrome or as a job lot of culls.

Good, strong tipping requires more liming than chrome leather. If the tanner will sort his hides after they are dehaired, he can have an extra lime pit and make up a medium strong lime liquor, and all hides with damaged grain can be put into this lime for 24 to 48 hours, and then be put through the regular system of washing, working out, bating, etc. After having been bated down well (tipping stock should be

bated low, to make a soft, strong leather), the hides should be started to tan by tacking them on sticks and suspending them in a weak sour liquor. If a non-acid tanning agent is being used, the liquor should be turned to the acid side by the use of lactic acid. The first liquor should stand about 7° test with a barkometer. Allow the hides to remain in this sour liquor for 48 hours, then handle them over into another pit, or else draw off the sour liquor and pump on a fresh sweet liquor of 10° strength. If handled over into the next pit, the hides should be pulled out and laid in a pile to drain for two hours in order that they will not carry too much of the sour liquor into the next pit. Allow them to remain in the 10° liquor 48 hours, then work them into a 12° liquor for 48 hours. Next work them into a 16° liquor and allow them to remain 4 days, but they must be handled each day and their positions changed, so that they will not have raw or "kissed" spots on them. After having been in the 16° liquor the required period, the hides are worked out into a 20° liquor and allowed to stay therein 6 days, when they are pulled down from the sticks and allowed to lie in a pile 48 hours. They are then pressed or put through a wringer so that they will be in condition for splitting, or they can be run through a splitting machine with a corrugated roll without pressing or wringing. If pressed or put through a wringer, they must be jacked on a stoning-jack to remove all marks.

After having been jacked, they are split at a 2½ oz. gauge, and the grains are then re-tanned in a mill with sumac, using two pails of sumac to each dozen sides. Boil the sumac in about 20 gallons of water, and allow it to stand until cool, then put in the leather and run 1½ hours, take the leather out and put it into a pile for 24 hours; then give it another run in sumac liquor made in the same way. The leather is piled down again and allowed to rest for 24 hours. It is then dipped into a tub of warm water to wash off the sumac, and after that is scoured on the table. While on the table, give the leather a good coat of moellon degras, made by dissolving 4 oz. of potassium carbonate in 3 gallons of hot water and

then stirring in 2 gallons of the degras. The leather is given a light coat of this slush, well rubbed in with a brush. It is now folded together and laid in a pile for 24 hours, then tacked out on frames. When dry, it is buffed by hand, and either staked or soft-boarded and pin-blocked to soften, when it is ready to japan. De-greasing is unnecessary when a first-class moellon degras is used.

*Another re-tanning process.*—A good way to fit bark-tanned leather for patent shoe tipping is to split and shave it on the machine, then for 50 medium sides dissolve 3 lb. of potassium carbonate in 50 gallons of warm water and run in a mill for a half-hour, then drain and wash for 15 minutes, when the leather will be in good condition to be re-tanned.

The re-tanning liquor is made as follows: Boil 2 pails of sumac in 40 gallons of water for 10 minutes, and allow to stand over night. In the morning dissolve 13 lb. of gambier and 10 lb. of salt and add the solution to the sumac liquor. There should be 50 gallons of liquor. Run the sides in this liquor one hour, using it at 80° F.; next pile them down on the floor for 12 to 24 hours, and then wash off the sumac in a tub of water.

## CHAPTER IX

### VEGETABLE-TANNED SOLE LEATHERS

**Rapid tanning processes.**—In modern plants, sole leather is tanned in hangers and layaways, and then made plump and solid by being drummed in strong liquor made from quebracho or bark extract. As the drum revolves, the extract is forced into the leather, which absorbs the condensed tanning material in a few hours. Before this is done, however, the leather, already fairly well-tanned, is run through the wringing machine and the surplus liquor is forced out.

Some tanners use whole hides, and by having plenty of liquor in the drum, get good, smooth grain on their leather. The grain should be well set before the drumming in extract is begun The extract is mixed with sweet liquor heated to 80° F.; it is also used in liquid form as taken from the tank or barrel The leather, when the drumming is completed, is removed from the drum and placed in warm water for a few hours, which plumps it; it is then oiled, dried, sammied, and rolled once or twice. When the preliminary tanning is done properly, the finished leather is well-tanned, plump, solid, and has good weight. Quebracho extract in concentrated form is the material usually preferred for the drumming process. Apparently firm and solid leather is obtained by using glucose, which makes plump flanks, bellies and shoulders: but the plumpness and solidity thus acquired are not real, and the leather does not give satisfaction.

The only way to make durable sole leather is by using nothing but vegetable tanning extracts. Some tanners, after the drumming in extract is completed, hang the leather in strong liquor made from the extracts from the drum; then they bleach it with acid and soda; oil it and hang it up to dry in a well ventilated but darkened room: and then roll it

for market. A mixture of equal parts mineral oil and cod oil is often used for oiling sole leather. Soluble or sulphonated oil is also drummed into the leather and adds to its pliability and strength. When the drum process of tanning is used, it is the practice of some tanners to send the old drum liquors to the handlers. These drum liquors are entirely sweet, and do not contain enough free acid to plump the hides properly while they are in the handlers; hence it is necessary to add lactic acid to the liquor in order that there may be the requisite proportion of acid to plump the hides. Not only is it advisable to add the acid to the head-handler liquor, but also to the handlers half-way down the series, in quantities growing smaller from the head liquor. The green hides are given a week in the handlers; next they go through a roller press or a wringer, and are then ready for the drumming process. During the latter process, the two essentials are the maintenance of the strength of the liquor, and keeping the leather comparatively cool. When the hides are found to be heating, they should be allowed to cool off before proceeding with the drumming, and the old liquor run to the handlers and fresh liquor supplied to the hides.

Neutralizing the lime in the hides by hanging them over night in cold water containing lactic acid, which also plumps them before putting them into the handlers, considerably shortens the period they have to remain in the handlers. Tan liquors at this time usually contain too little acid to neutralize the lime and keep the hides plump, and some process of de-liming is necessary. Lactic and acetic acids are commonly used in tan liquors. Butyric acid also is used for de-liming, and is an excellent plumping acid for the early tan liquors. Some tanners drench their hides with boracic acid, which not only removes the lime, but also gives the grain a smooth, silky feel and appearance.

Some tanning extracts are more astringent than others, and when several tanning materials are being employed it is best to use the less astringent materials during the first or earlier stages of tanning, and use rockers so that the hides can

be kept in motion and penetration by the liquor facilitated. The earlier liquors fix the grain and give it good color, and they should be weak. When the grain is colored and set, the hides are in condition to receive stronger liquors. The strength of tanning liquors should be increased rather slowly to prevent thickening the grain and a wrinkled or drawn appearance. When strong liquor is used during the early stages of tanning, the exterior of the hides may be so hardened that penetration by the liquor into the interior becomes impossible. Smooth grain and fibers completely tanned are obtained only when the rate of increase of tannin strength is very low.

Sole leather is sold by weight, and as the cost of the hide is from 50 to 70 per cent of the cost of the finished leather, the tanner's main object is to produce as many pounds of leather as possible from a given weight of hide. Whatever degree of success he may have is spoken of as a "gain." Thus, for 100 lb. of green-salted hides the tanner can obtain from 60 to 80 lb. of leather, so he has a gain of from 60 to 80 per cent; but from 100 lb. of dry hides he will make from 150 to 185 lb. of leather, and so has a gain of from 150 to 185 per cent.

For the manufacture of sole leather, either green-salted, dry-salted, or flint hides may be used. In the preparatory treatment they are soaked, washed, unhaired, and fleshed as already described. They are then placed over sticks and suspended in cold water over night. It is not customary to bate hides for this class of leather.

Three general methods are used in the manufacture of sole leather, namely, oak, hemlock, and a combination of both, known as union. True oak-bark tannage is practically a thing of the past, and what is sold as oak is in reality chestnut oak. Hemlock leather is produced by the methods acid and non-acid.

**Oak leather.**—Leather made from hides that have been tanned with oak bark is distinguished by its light color and firm texture. This tanning material imparts a bloom to the leather which may or may not be removed, according to the

demands of the trade; if it is removed, the leather is spoken of as "scoured."

On removal from the cold pool, the hides are ready for the actual tanning process. They may be carried through as whole hides, but they are generally cut into sides before entering the rocker. The rocker system consists of a series of vats 8 ft. long, 6 ft. wide, and 5½ ft. deep arranged so that the liquor from the bottom of one pit overflows into the top of the next. The liquor is supplied to the head or strongest liquor vat containing the most tanned hide, and gradually works its way through all of the vats in succession, being weakened or sapped in each by the presence of the hides. It finally reaches the tail rocker-vat where it meets the fresh hides, and then flows to waste or is pumped over the leaches. The stock suspended on the frame of the rocker is moved slowly up and down, which serves the double purpose of agitating the liquor and producing an even color on the grain. This rocking also hastens the tannage, and by preventing the hides from touching removes the danger from untanned places known as "kiss spots."

The rocker liquor, being acid in character, serves to neutralize the lime present in the stock, and at the same time produces a swelling or plumping effect on the hides. Much care is necessary during this operation, as the quality of the leather is determined by the attention given to the hides while they are in the rockers.

The liquor used in the rockers should contain sufficient acid to perform its function as mentioned, and in the tail liquor is usually about 0.6 per cent. This acid is produced naturally by fermentation of the glucosides, or may be obtained by adding lactic acid. The strength of the tail rocker liquor should be about 10°, and 18° in the head rocker.

The time that the hides remain in the rockers varies according to local conditions, but 15 days is about the proper period. The hides are in a plump condition on removal from the rockers, and the grain is sufficiently tanned to withstand the astringent action of the stronger liquors.

After the rockers, the hides are treated in the layers. These layaway vats are usually somewhat larger than the rockers, and as a rule the hides from three rockers can be accommodated in one layer. In these layers the hides are laid out flat, one at a time, and sprinkled over with coarsely ground bark. When the hides are set, a concentrated solution of the tanning material is pumped in until the pit is full, and the hides are allowed to remain undisturbed for a definite period, as given below.

Some tanners prefer to substitute the first layer pit by a press layer system. In this case the hides are thrown into the pit, but no ground bark is used. Strong liquor is added to the head press-layer pit, and gradually, by overflowing from one pit to the next, presses the weaker liquor towards the tail-press layer. The time of treatment in the press layer is usually about 8 days and the strength of the liquor runs from 20 to 28° barkometer.

Where still layers are employed, the time in the first layer is usually about the same as for a press layer, or about 8 days. Whether the layer be still or a press layer, the sappage is fairly high, owing to the fact that the stock is in a very receptive condition at this stage.

From the press layer or first layer the hides are transferred to other layers, the number and strength of which depend largely upon the idea of the individual tanner, but commonly three or four. These layers are sometimes spoken of as "handlers" or "dusters."

The following schedule represents typical practice in an oak-bark tannery:

| *Treatment* | *Time, days* | *Strength of liquor degrees barkometer* |
|---|---|---|
| Rockers | 15 | 10 to 18 |
| First or press layer | 8 | 20 to 28 |
| Second layer | 12 | 34 to 38 |
| Third layer | 16 | 36 to 38 |
| Fourth layer | 25 | 40 |
| Fifth layer | 32 | 50 |

In the above description of an oak-bark tannage it is assumed that the agent is true oak bark.

When the tannage is complete, the sides are taken from the last layer and thrown into warm water to clean the grain from sediment. After rinsing, they are piled up to drain. They are then swabbed with cod oil or a mixture of this and mineral oil, and hung on sticks in the drying loft. This loft is so arranged that the window may be closed and darkened at the start, and heat and a good circulation of air provided later. This is an important factor in the proper drying of sole leather, as drying too quickly causes a cracky grain, while drying too slowly results in mold.

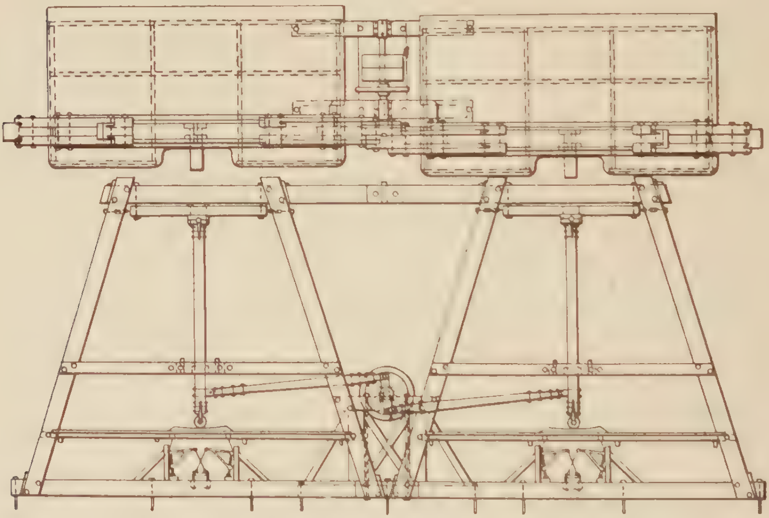

Figure 69.—Sole leather rolling-jack.

When thoroughly dry, the sides are removed from the loft, brushed with water, and placed in piles to sammie. The properly tempered sides are oiled on the grain and rolled. They are then returned to the loft, and when dry are ready for market. The rolling is accomplished on a machine consisting of a heavy beam on the side of which is a brass wheel (figure 69). This wheel is about 8 inches in diameter and has a 6-inch face. The leather is held under the roller on a brass bed conforming to the arc described by the roller. A foot lever raises the bed and thus produces the necessary pressure.

Rolling serves to smooth the grain and compress the leather at the same time imparting a desired polish. Owing to a demand for a full cutting leather, the above procedure is often modified. This is especially true in the case of extracting and loading leather, the process for which will be given in detail under the head of union tannage.

**Non-acid hemlock tanning.**—As a rule, dry hides are used in the manufacture of non-acid hemlock leather. After soaking, depilating, de-hairing, and fleshing, the hides, which have been cut into sides, are run in the paddle for a few hours with an acid color liquor consisting of spent liquor from the tail handler of about 8° bk., and containing about 0.6 per cent of lactic acid. They are then toggled together and placed in the tail handler pit. The handler pits are arranged in series like the rockers described, that is, the strong liquor enters the head pit and is then pressed toward the tail by flowing from the top of one pit to the bottom of the next. During the flow of liquor through the series there is a sappage of about 6° bk., the liquor entering the head handler from 14 to 18°, and leaving the tail handler at about 8°. By means of a power-driven reel the sides are changed several times each day for the first three days, being pulled and replaced in the pits. This changing exposes more surface to the action of the tan, at the same time stirring up the liquor. After the third day, and each day thereafter, the hides are reeled forward into the stronger liquor until the head handler is reached. The time in this handler is from 12 to 15 days, during which time the stock has become plumped and the grain well set. On removal of the sides from the head handler they are untoggled and placed in the first layaway. The strength of the first layer is about 20° bk., and is usually an old liquor that has been sapped in another layer. The hides remain in the first layer for 7 days. They are then pulled and transferred to the second layer, where they remain for 11 days, starting with a 22° liquor. This solution is also a sapped liquor from a stronger layer. The third layer liquor stands at 23°, and in it the stock remains for 12 days. This solution is usu-

ally made fresh from leach-house liquor strengthened with extract. In the fourth liquor the hides are allowed to remain for 20 days, the strength being 25°. The fifth layer should have a reading of 28°, and the stock should remain in it for 21 days. The sixth-layer liquor should stand at 30° and the time should be 28 days. In the fourth, fifth, and sixth layers the solutions are made from sweet liquors from the leach-house, which have been strengthened with extract. The sapped liquors from the first, second, and third layers are used as handler liquors, while these layers are made up from sapped liquors from the fourth, fifth and sixth layers.

The reason for this particular method in handling the yard liquors is based upon the fact that the hides require a certain amount of free acid to produce the necessary plumping in the early stages of tanning. This acid is produced by fermentation of the liquors. By the time the stock reaches the fourth layer the plumping is complete, and so the hides should then only be treated with acid-free liquor. The reason for increasing the strength of the liquor is due to the fact that, after the tanning content of the hide equals that of the liquor, no more tanning will take place. In other words, the strength of the liquor should always be greater than the tannin content of the hide. The stock, on coming from the last layer, is thrown into a pool of warm water to remove the sediment from the surface of the leather, or it may be washed in a drum. From this point on the leather may be finished as will be described under union tannage.

**Acid hemlock leather.**—By this is meant a variety of hemlock sole-leather which has received its plumpness by means of sulphuric acid. The bulk of acid-hemlock leather is made from dry hides which have been de-haired by the sweating process. The hides, as they come from the beam-house, are placed in color vats, where they come in contact with spent liquor, which gives them a surficial tannage on the grain and sets the color. After this treatment they are suspended in a 0.1 to 0.3 per cent solution of sulphuric acid where they

remain until the desired plumpness is secured, and are then ready for the tanning liquor.

The hides go direct to the first layer liquor, and on account of the abnormal plumping it is not necessary to start with weak solution as is the case with other tannages. There are, therefore, no rockers or handlers in the acid-hemlock process, but strong liquors are employed from the start. The stock enters the first layer which is 38° bk., and remains in this liquor for 8 days. During this time the liquor is sapped to about 20°. The density, however, is no indication of strength of the liquor, for the reason that the hides carry in sulphuric acid and sulphates which materially raise the gravity. The spent liquor, therefore, is run to waste as its sulphuric acid content retards the absorption of tannin. Some tanners have made the mistake of returning the spent liquor to the leaches. When this is done, the whole yard eventually becomes saturated with sulphuric acid, and no tannin can be taken up by the hides. From the first layer, the sides are transferred to a second layer, where they remain for 11 days. The second layer liquor has a strength of 40° bk. The sapped liquor from the second layer becomes the strong liquor of the first layer. If low in barkometer, the spent second layer liquor is sometimes built up with strong liquor from the last layer.

In an acid-hemlock yard the leach-house liquor is usually built up to strength with extract, either hemlock or chestnut extract being used. Any excess of liquor from the second layer, as well as the sapped liquor from other layers, is returned to the leaches, and made up to strength by further leaching and by the addition of extract.

From the second layer, the stock is transferred to the third layer, where it remains for 15 days with a density of 42° bk. at the start. In the fourth layer the hides remain for 24 days, the strength of the liquor also 42°. Treatment in the fifth layer is for a period of 24 days, the initial gravity being 44°. The sixth layer has a gravity of 48°, and in it the hides remain for 27 days.

From the sixth layer the hides are thrown into a warm pool to remove the excess of liquor and clear the grain. They are then extracted and finished as desired.

**Union leather.**—A combination of hemlock with chestnut oak extract gives a satisfactory leather, and one having a color closely resembling oak-tanned stock. The combinations used

Figure 70.—Mechanical transfer in the tan-yard, showing pack going to rocker.

are as numerous as there are tanneries producing this grade of leather. In some plants the tanner depends upon his leaches for making the combination liquor, while others depend entirely upon extracts for this purpose. Although, strictly speaking, a union tannage is supposed to be a mixture of hemlock and chestnut, it will be found that many tanners add other extracts such as quebracho, mangrove and myrabolans. Most of the union leather is cropped; that is, the bellies and shanks are cut from the sides, leaving what is known to the trade as a "bend." These bends bring a higher price than the same

leather sold in sides, because they can be cut to better advantage in making soles. The bellies are used for inner-soling, where less wearing quality is required.

Green-salted hides are generally used for making union leather. They are soaked, limed, de-haired, fleshed, fine-haired, and placed on sticks in the cold pool over night, when

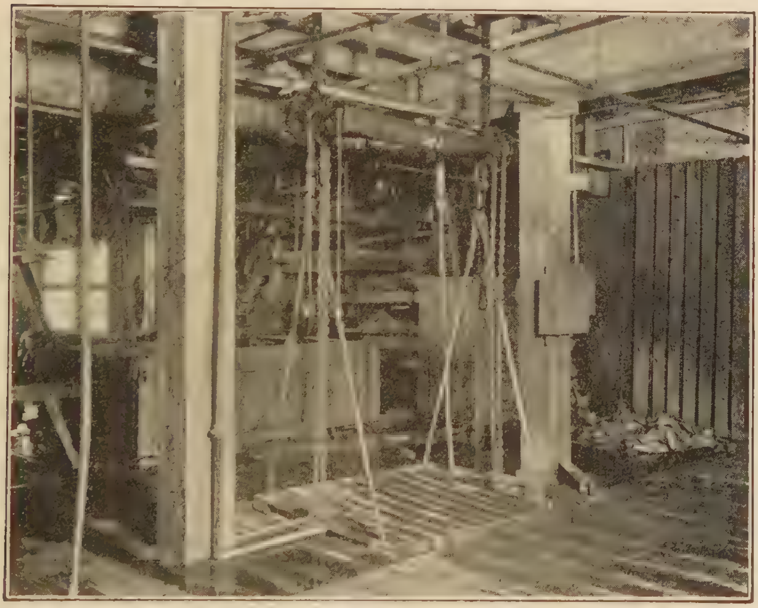

Figure 71.—Mechanical hoist for moving hides.

they are ready for the rockers. The rocker-pits (figure 70) are arranged in series, usually in two rows, connected in such a manner that the liquor in them may be pressed forward, up one side and down the other; in other words, a sort of an exaggerated circle. Fresh stock from the beam-house is put into the tail pit, which contains no liquor. Fresh liquor from the extract-house or leach-house is pumped into the head pit, which contains the hides that have been in the rockers the longest time. As the strong liquor enters the head pit, the liquor in it overflows to the bottom of the next pit, which in turn overflows to the next, and so on until the tail pit is full.

To secure an empty pit for the next pack, the hides in the most advanced pit are transferred (figure 71) to the layer, and the liquor in that vat is pumped to the next in the series. The overflow causes a change of liquor throughout the series. The liquor in the tail pit may flow to waste, or it may be pumped back to the extract or leach-house. The common prac-

Figure 72.—View in the tan-yard, showing series of layers.

tice is to pump back twice to leach-house and once to waste.

The frames on which the hides are suspended rock slowly up and down, thus preventing the setting of insolubles, assisting in the production of uniform color and penetration, and obviating what are known as kiss spots.

The greatest care should be exercised in the rockers, as it is here that the character of the leather is formed. Attention must be given to the strength of the liquor, and the amount of free acid and tannin carefully checked. Under no circumstances should the rocker liquors be mixed with those from the other parts of the yard. Barkometer readings may be

taken to assist in regulating the liquor, but they are not a safe guide without occasional laboratory checks.

Assuming a rocker system in which the hides remain for 15 days, in the tail-pit there should be from 0.5 to 1 per cent of tannic acid and from 0.25 to 0.33 per cent of free acid, estimated as acetic. These should increase gradually un-

Figure 73.—Cropping.

til in the head rocker there should be $2\frac{1}{2}$ per cent of tannic acid and 0.6 to 0.7 per cent of free acid, estimated as acetic.

Assuming again that the union leather is being made with an extract tannage, the proportion should be as follows:

| *Tannage extract* | *Per cent* |
|---|---|
| Chestnut wood | 15 |
| Chestnut bark | 45 |
| Hemlock bark | 40 |

On removal from the rockers, the hides next enter the press layers. These consist of a series of vats arranged in somewhat the same manner as the rockers, and the liquor is pressed

forward in the same way, working from head to tail pit. The hides are taken from the rocker frame and thrown into the empty tan pit one at a time. Over each hide is dusted some chestnut-oak bark, before the next hide is placed in position. This powdered bark tends to keep the hides separated, and so allows more uniform contact with the liquor.

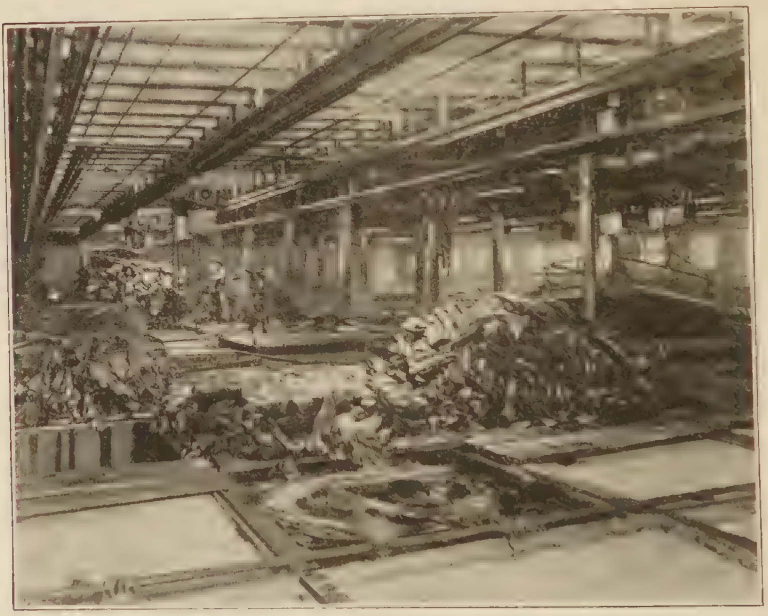

**Figure 74.—Cropped hides and bellies ready for final layer.**

Numerous methods are employed for handling the stock in the press layers. A common method is to have two rows of five vats, the number of the series depending upon the size of the tannery and the quantity of stock being treated. One pack enters and one is removed from this set of layers every other day, thus making 20 days required to work the hides through the press layers. The liquor in the head press layer should stand at about 40° bk., and should contain 4 per cent of tannic acid and about 0.6 per cent of free acid as acetic. During the passage through the press layer the liquor should be sapped so that in the tail press layer there should

be about $2\frac{1}{2}$ per cent of tannin. A good combination for the press layer is as follows:

| *Tanning extract* | *Per cent* |
|---|---|
| Chestnut wood | 20 |
| Chestnut bark | 45 |
| Hemlock bark | 35 |

The hides for the press layer are next transferred to the first layer liquor. The layer-pits (figure 72) are not connected

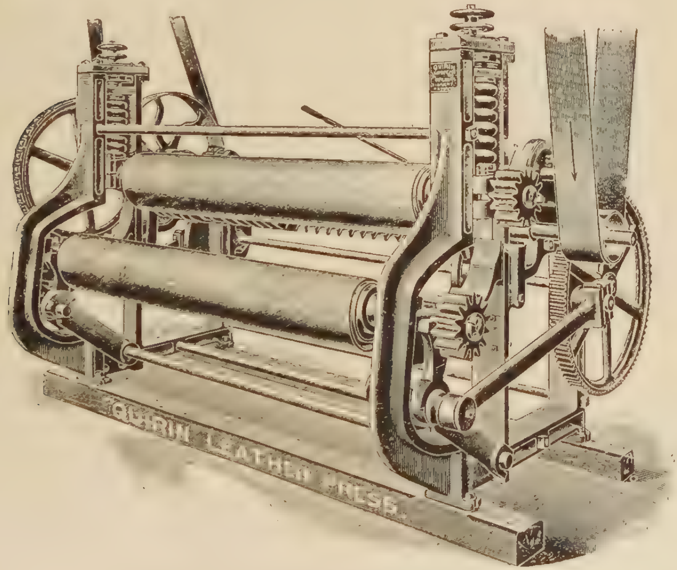


**Figure 75.—Quirin press or wringer.**

with overflow as is the case with the rocker and press layers, and the liquor in them is not changed during the 7 days that the hides remain in them. No bark is used for dusting in the first layer, and the strength of the liquor should stand at 42° bk. The tannin content of the first layer should be about $4\frac{1}{2}$ per cent, and should be made up as follows:

| *Tanning extract* | *Per cent* |
|---|---|
| Chestnut wood | 25 |
| Chestnut bark | 40 |
| Hemlock bark | 35 |

The temperature of the first layer liquor should be 95° F.

The second layer liquor is made up of the same materials

and proportions as the first layer, except that the density is raised to 46° bk. and the tanning content therefore increased to 5 per cent. The hides remain in the second layer for 12 days, during which time they are not removed or the liquor changed. On removal from the second layer the hides are cropped (figure 73). The cropped backs are placed in the

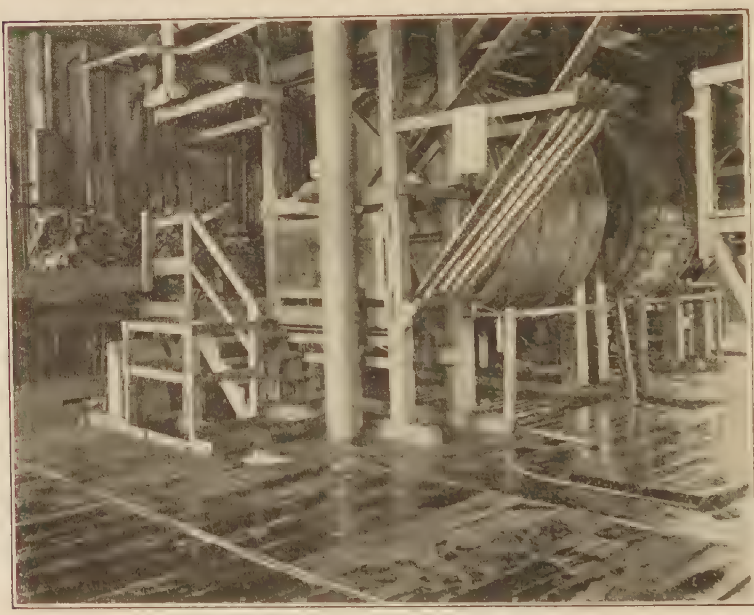

Figure 76.—Extract wheels.

third layer pits and the bellies thrown in on top (figure 74). The liquor in the third layer is made up entirely of quebracho extract at a density of 55° bk. and at a temperature of about 115° F. No bark is used to dust the backs, and they remain in this liquor without changing for 35 days.

*Extracting.*—As the hides come from the third layer they are thrown into water at 100° F. for an hour, and then passed through the wringer (figure 75). The well pressed and fairly dry backs are next placed in the drum (figure 76), about 100 backs constituting a pack, and while the drum is in motion 500 lb. of 100° bk. quebracho extract at a temperature of

150° F. is pumped in. The drum is run for $1\frac{1}{2}$ hours, by which time practically all of the extract has been absorbed From the extract wheel the backs go to the tempering pit, which contains a quebracho extract of 45° bk. and at a temperature of 80° F., where they remain 4 days.

*Bleaching.*—On removal from the tempering pit, the backs

**Figure 77.—Ready for the bleach.**

are suspended on sticks (figure 77), and hung for 7 minutes in fresh water at a temperature of 125° F. The frame is now lifted, and the hides immersed for 7 minutes in a weak alkali solution (figure 78), the strength being 0.3 per cent of sodium carbonate on the weight of the water, and the temperature 125° F. From the alkali the backs pass to the first acid dip, in which 1.5 per cent of sulphuric acid on the weight of the water is used. The time and temperature are the same as for the other treatments. The backs now go to a second acid solution which, however, is somewhat more dilute. To remove the excess of acid the leather is dipped in

plain running water for 7 minutes. After bleaching, the hides are passed through the wringer, and are ready for loading. Figure 79 shows a cross section of a standard bleaching machine.

The bellies from the third layer are not extracted, but after washing in warm water are bleached in the same manner as

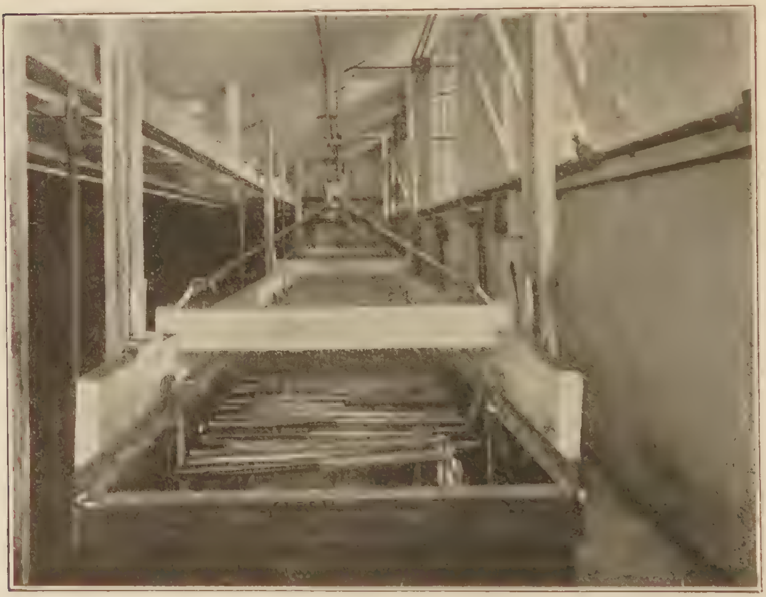

**Figure 78.—Hides suspended in the bleach.**

described for backs. They then receive the same finishing treatment as the backs.

The hides, as they come from the wringer, are placed in a drum (figures 80 and 81) and about 50 lb. of crystal magnesium sulphate is added for each 100 hides. The door is then closed, the mill started, and a mixture of 175 lb. of glucose, 6 gallons of sole-leather oil, and 1 gallon of cod oil, at a temperature of 150° F., is added through the trunnion. The stock is run for a half-hour. The hides are then set out on a Quirin press and go to the loft. The dyeing of sole leather must be carried out with great care, otherwise a dark and brit-

tle grain is likely to result. The usual procedure is to hang the leather over sticks, and for the first two days keep the loft dark and as cool as possible, but with proper ventilation. The temperature of the loft is then gradually raised and light admitted. The time required for dyeing varies with the climate, season of the year, and conditions of the loft.

Figure 79.—Bleaching machine.

When the leather is thoroughly dry it is taken down and dipped in warm water containing a small quantity of glucose and then piled down to sammie, which takes from one to two days. When properly tempered, the grain is wet uniformly with warm water, and given a coat of cod oil. While still in this damp and oily condition the leather is set out and rolled for the first time (figure 83). The rolled stock is again taken to the dry loft (figure 84), and this time suspended by one end (figure 82), and when dry is again rolled. Some tanners apply a seasoning after the first rolling, which adds to the appearance of the leather on re-rolling. In place of the second rolling the leather is sometimes seasoned (figure 85) and brushed on the machine shown in figure 86. After the second rolling or brushing the leather is ready for sorting and grading for market.

**Rapid sole leather tannage.**—On account of the immense sum of money represented in hides tied up in the process of making sole leather, many rapid tannages have been proposed, some of which are of proved merit, while others are

entirely valueless. Practically all of the rapid tannages depend on constant agitation of the hide in the presence of the tanning agent. It is in the method of securing this agitation that the various systems differ. Most of the quick tannage processes, however, are still in the experimental stage, but whether they will be able to compete with the old-style methods remains to be seen.

One of these rapid tanning processes depends for its effi-

Figure 80.—Placing in loading wheel.

ciency upon rockers arranged as described under the regular sole leather process. The hides, on coming from the beam-house, are suspended in frames and treated just as given under union tannage. On removal from the rockers they are at once put in the drum, and wheeled with strong extract for a period of from one to several days. They are then bleached and finished in the usual manner.

Some processes depend upon tawing with alum and salt to set the grain before entering the strong liquor.

Many processes have been patented in which the use of a revolving drum is the principal feature. The size, shape, and arrangement of the hides in the drum are all features which have been patented. Some drums are provided with frames to which the hides are attached, thus causing the liquor to fall over the stock. In other processes the hides are fastened to hooks in the drum. In all of the methods the grain is first set with dilute liquor, and then the concentrated extract is applied.

**Figure 81.—Removing from loading wheel.**

The chief objection to rapid tanning is the low gain, although this may be counteracted by loading. The following complete description of one of the rapid tanning processes may be of interest:

*Tanning with chestnut extract.*—This extract, prepared with care, is practically a pure solution of chestnut wood tannin, rich in tanning power per unit of density, and soluble to a high degree. It will form liquors free from sediment or liquor-filth, well balanced in tannin and non-tannin for oak

and hemlock yards, and suitable for tanning hide fiber quickly and thoroughly.

For color reasons, chestnut extract should be well incorporated with the leach liquors. Its natural color is brown, but it becomes red by treatment. Mix as much as 75 per cent with the leach liquors, and the bark color will dominate. Tan the

**Figure 82.—Setting-out after tempering.**

stock in chestnut alone and the color will be "on the brown." This is the only color secret in the use of chestnut extract. Put the extract on the head leach, through the sprinklers, or a little at a time as the leach fills with bark, and take down the liquors in the customary manner, making the draw of the desired barkometer average. As the yard becomes saturated with the cnestnut, several things will be observed—the packs will feed more rapidly, they will "stand up" higher, and the plumpness put into the stock in the sours will hold up to the rolling room. This is because the liquors sent to the stock are richer in tannin per unit of barkometer, without an in-

crease of the liquor-filth which impedes entrance of the tannin into the fiber of the stock. Leather is made in the beam-house and the sour end of the yard; almost anything can be done to it if proper beam-treatment and plumpness are parts of its record. After the handler period is past, the stock should enter the heavier liquors in a condition of plumpness


**Figure 83.—Rolling-jacks.**

and grain desired in the finished product, and from that point forward it should be struck steadily and persistently, with such frequent shifting as will keep the feeding process continuous.

The function of chestnut extract is thus made clear: It is simply a tanning agent with souring properties midway between hemlock and oak, aiding the handlers in one and restraining them in the other. No other extract possesses this unique property. The amount of combined tannin that can be put into a hide depends almost wholly upon the degree in which the initial plumpness is retained during the passage of the stock through the true tanning liquors, those beyond the

handlers. If these liquors are clean and grade up from 20° bk. in the first layer to from 50 to 60° in the last, the combining process will proceed uniformly and steadily, flanks will be full and firm, the cut will show as much color from the one side as the other, and the "white streak" will be firm and plump. Such leather has good market qualities, and also has

Figure 84.—Drying-loft.

more room for finishing material and a larger area of hide-fiber to take the tannin. Chestnut extract promotes exactly these conditions, with, at the same time, a beneficial effect on the sour end of the yard.

There are various ways of using this extract: Some tanners put it directly on the leaches, and there allow it to dissolve and percolate through the ground bark. The chief advantage claimed for this is that the disagreeable bluish-gray color on the stock is avoided. Other tanners dissolve the extract in a separate tank and then run it on the leaches through the sprinklers. Others prefer to dissolve the extract separately,

then mix the solution with bark liquors as they come from the leach-house. These methods, however, are not the latest nor the most approved, practical experiments having shown that chestnut extract is used most successfully along other lines, which may be described as follows:

The hides are soaked, fleshed, limed, and de-haired in the

Figure 85.—Applying the bright finish to sole leather.

usual way. After de-hairing, they are well worked on the grain, then left hanging over night in the cold water pool, to which lactic acid has been added. For ordinary packs, 40 lb. will be sufficient. As they are plumped, and the fixed lime is also neutralized, the ordinary time in the handlers may safely be considerably reduced. Coming from the cold water pool, the hides should again be washed on the grain before going to the liquors. The green pack is given a week in the handlers, which are soured to the proper degree by addition of lactic acid. The hides go from the handlers through the first two layers until struck, after which they are run

through a roller press, and are then ready for the drumming process.

The extract is poured into hot water, and the solution is run on the stock through the gudgeon at about 16° bk. The drum is revolved slowly at first. The two essentials at this stage of the process are the maintenance of the liquor strength

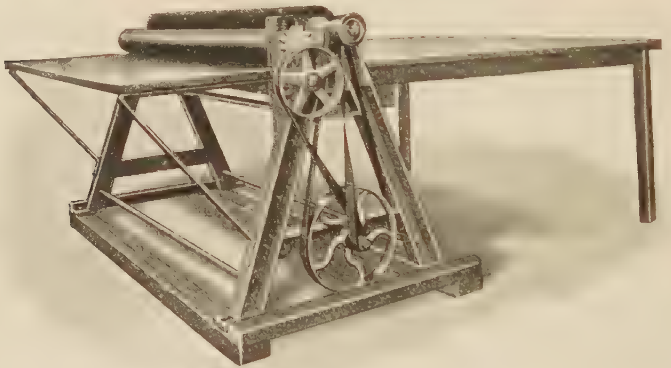

Figure 86.—Brushing machine for sole leather.

and keeping the stock comparatively cool. When the hides become warm, they should be withdrawn and allowed to cool. During this interval the old drum liquors are run to the handlers and new liquor is supplied to the drums.

After the leather is thoroughly tanned, weight is given by putting it in a drum together with a certain amount of undissolved extract, and then drumming long enough to have it absorb the extract. It is then finished as usual. One of the advantages of the drum system is that entirely sweet liquors can thus be given to the stock, since the natural resistance of the fiber to the penetrating power of the tannin is overcome by the agitation. However, it can readily be seen that the old drum liquors sent to the handlers will not contain a sufficient amount of free acids—other than tannin—requisite for the holding of the plumpness of the hides; hence it is necessary to add lactic acid to the handlers so that the proper relations of the acids may be maintained. As there is an absence of natural lactic acid, the best results are obtained

by adding the commercial article to the head handler liquor in the proportion of 1 lb. of lactic acid to every 100 lb. of hides, green weight. Besides adding to the head-handler liquor, it is advisable to add lactic acid to the other handlers half way down the series, in quantities growing smaller from the head liquor.

Chestnut extract is a valuable tanning material for manufacturers of heavy leather, its tannin being so easily available it is one of the most acceptable on the market. Light skins, prepared as for any other tannage, may be tanned by suspension in chestnut liquor or drummed in liquor made direct from the extract, or from a mixture of two extracts. Skins intended to be colored subsequent to tanning are usually tanned direct in the extract liquor, with occasionally a re-tan in sumac. Stock to be run in the natural color is usually struck in the mixture, giving the shade desired. With very thin leathers, the main requirement of the tanning material is that it shall be clean, bright, and quick in action.

Light hides for side leathers are first put through a series of sour liquors, in which they are plumped. The liquors are prepared by direct solution of the extract in water or freshly made bark liquor; thus prepared, they are given sweet to the nearly struck goods, usually as layaways, not infrequently in revolving drums. These stocks are always tanned out in relatively weak liquors, rarely exceeding 15° bk., as freshly prepared. Tanning is then completed in drums. Where a particular color quality is desired, the leather is re-tanned with suitable material, such as gambier, mimosa, quebracho, sumac, etc., according to the shade or color condition desired.

**Drum tanning for sole and belting leathers.**—In using quebracho, 85 per cent, and oak, 15 per cent, a first-class piece of leather can be made, by carrying out the following process: After putting the hides through the beam-house, a 4° liquor is made of quebracho and oak extract as mentioned above. In preparing these liquors, make up 3,000 gallons of 4° solution in the cooler, then add 4 gallons of acetic acid and 1 gal-

lon of dermiforma. After standing 5 or 6 days, run the liquor on to the green hides. Strengthen each day with enough liquor to fill each rocker for green hides in turn. Raise the liquor 3° daily until the strength is 20° bk. Add each day 1 gallon of dermiforma and 6 quarts of acetic acid, then feed from head rocker, keeping liquors at 20 to 22°. Never have the tail liquor above 4°, as quebracho extract penetrates much faster than oak extract. It is safe if the tail falls to 3°, but it is best to keep it at 4°. There should be 10 rockers in a section, and the hides should hang 20 days. Then take them from the rockers and crop them for the drums.

Put 50 backs in a drum, fill the drum two-thirds with 75° liquor, and run for 48 hours without changing the liquor, but watch the temperature and keep it below 105° F. After the 48 hours, discharge all of the liquor and fill again with 75° liquor, filling the drum only half full this time. The drum should be large enough to hold 25 barrels when half full. Drum 24 hours, when the hides will be tanned throughout, plump and of fine color.

The hides must be well toggled together—grain inside—to prevent the grain being damaged by rubbing together. After a 72-hour run, take the leather from the drum, and lay it away in a 75° liquor for 4 days. Put 300 backs into a vat 8 by 9 by 6 feet, with 50 lb. of sumac to 100 backs. On the fourth day, raise the stock, run it through a wringer, and put it back into the drum. Add 3½ lb. of quebracho extract to each back, dissolved and not diluted. Put 50 backs into the drum with 175 lb. of extract, and drum for 30 minutes. Then take them from the drum and throw into a sour liquor. It will be found that by running the backs through the wringer or press the extract will penetrate much better, and little will remain on the surface. The sour liquor should be 25 to 30° bk. After lying in the sour liquor for 24 hours the leather is ready for bleaching. It is advisable to scour lightly on the grain. Have one pit holding 750 gallons of water, two of the same size for soda, and two for acid. Put 22 lb. of soda ash in the first pit and 3 lb. in the second; also 30 lb. of

sulphuric acid in each, and heat to 125° F. Hang 8 backs in each pit; strengthen after every 40 backs, putting 4 lb. of soda into the first pit, but none in the second, as pulling stock from the first to the second will maintain the soda content in the second pit. Also add 4 lb. of sulphuric acid into each pit for 40 backs. From the pits the backs are put into clear water for 2 hours; then oiled, and run through the press or hung up to drain; preferably the latter, as the press draws more or less extract to the surface. For oiling use ¾ lb. of cod-liver oil, or a mixture of this and a mineral oil. Regarding sugar and glucose, putting them in with the oil and then drumming is the cheaper method, but best results are obtained by re-tanning.

When dry, dip the leather into water for rolling. If properly looked after in the rolling room, the backs will look just like vat-tanned oak backs, only they will be firmer and of a brighter color. From 70 to 75 per cent finished gain can be made by this process.

# CHAPTER X

## BELTING LEATHER

The description of belting leather in this chapter is taken largely from a lecture given by F. H. Small before the tanning and applied leather chemistry students of Pratt Institute, Brooklyn, N. Y., for which the author desires to give him credit.

**Necessary characteristics.**—Leather to be used in the manufacture of belting should have the following characteristics:

*Good driving surface*, with sufficient friction between belt and pulley to keep slippage small and enable the belt to carry its load when slack, whereby useless waste of power at the bearings is avoided.

*Lateral stiffness coupled with pliability:* Stiffness to prevent the belt from curling at the edges when shifted, and from twisting and waving; and pliability to enable the belt to hug the pulley, wrapping itself around to secure the largest possible arc of contact, and enable it to alter its shape with the minimum of internal resistance as it travels round the pulley.

*High tensile strength*, so that it may carry a heavy load without breaking.

*Little stretch but considerable elasticity:* Little stretch so that it will need to be shortened as seldom as possible, doing its work uninterruptedly; and elasticity that it may easily take up and let go its load as it travels round the pulley.

*Straightness*, so that it may run true on the pulleys.

*Resistance to external conditions*, (such as heat, moisture, chemicals, etc.) so that it may do its work in any place at any time enduringly.

*Low initial cost.*

It is generally admitted that leather comes nearer to preserving all of these qualities than any other material. Many of the qualities specified, however, are almost opposite, and it

is apparent at the outset that no material and no leather can meet all of the requirements with full satisfaction. Lateral stiffness is not compatible with pliability; elasticity rarely goes hand in hand with no stretch. The best we can hope to do, therefore, is to make a leather that will have the desired qualities in the largest degree, and in which we have compromised some of the incompatibles.

**Leathers used in belting.**—There are various kinds of leather used for making belting, but the most popular belting is that called "oak-tanned leather," the general conception of which is belting made from leather tanned with oak bark in the old way. While it might not be safe to say that after diligent search it would be impossible to find a small amount of leather that has been tanned in this way, the quantity would be a very small proportion of the whole. The terms oak, hemlock, and union have gradually grown to have less and less significance when applied to leather. This is not saying that there are no manufacturers using large quantities of oak bark in making their oak-tanned leather, but it is indicative of the general trend.

Bearing in mind that the term "oak-tanned" as used today stands in general for a "type of leather" rather than for a "true oak-bark tanned leather," the description of the manufacture of oak-tanned leather for making belting may then be understood.

It will perhaps be as well to mention the fact that by no means is all of a hide usable for making leather belting; in fact, ordinarily only about a third of the hide is so used, the part used being called a belting bend. For a cheap grade of belting, other parts of the hide, particularly the best part of the shoulder, are sometimes utilized.

*Raw material.*—The belt-maker, who is also a tanner, tans the whole hide, and his raw material is the green hide. The raw material of the belt-maker who is not a tanner is a market or belting butt, as belt bends are not commonly on the market. A belting butt is that part of the hide left after cutting off the bellies, head, neck, and tail. The bellies are

cut off at the flank on a line parallel to the backbone; the head and neck in a line at right angles to the backbone. This butt is divided by the belt manufacturer into a belting bend and a trimmed shoulder by cutting the butt at right angles to the backbone at a point 54 inches from the tail. The bellies, heads, and shoulder are collectively called the offal. The butt and offal are sometimes processed independently in the tannery, but the hide is at least started as a whole, and so we may begin our consideration of the leather manufacturing process by devoting a few moments to one of the raw materials—the hide.

Hides used for tanning into belting leather are commonly green-salted packer hides. They should be free from brands, and as far as possible free from flesh cuts caused by poor flaying, from scratches on the grain whether or not healed, and from grub-holes—whether or not healed. These all will constitute defects in the finished leather, and shorten the life of the belting made therefrom.

The take-off of American hides is reasonably good, more fault having to be found in this connection with foreign hides. Fortunately the scoring is usually worst on the belly and shoulder-parts of the hide, which are not used for belting; but the cuts in this case lessen the value of the offal.

Barbed wire is perhaps not as common now as some years ago, but at that, it is difficult to secure hides free from the scars, long and short scratches, each of which may possibly be the nucleus of a crack which is at first surficial, but will ultimately work into the leather deep enough to cause the belt made from it to give way.

It requires no argument to demonstrate the damage done to a hide by the larvae of the warble fly. These work their way out through the skin, leaving behind a hole, which, even though it may heal over, will always be a weak and unsightly spot in the finished leather. It is not an uncommon sight to see skins so full of grub-holes that they look as though they had been riddled by a shot-gun. Within recent years, however, the U. S. Department of Agriculture, co-operating with

the Tanners' Council, has done much to eliminate this source of damage.

**Manufacturing processes.**—For belting leather, the best hides will be none too good, so the first step in the process of leather making will be to secure the best hides possible. These hides will then need preparation for tanning, and are put through the regular beam-house processes of soaking, fleshing, liming, de-hairing, beaming, and de-liming. The old-time tanner who said that the quality of his leather was made in the beam-house, knew whereof he spoke, and the beam-house work will merit and demand the most careful attention.

The points of most importance in the beam-house practice when belting leather is to be made are as follows:

1. Good hides, sound, green-salted, unbranded, well flayed, and so far as possible free from grain scratches and grubs.

2. Thorough soaking.

3. Average liming, as for instance a 3 to 6-day liming in limes of progressive sharpness and newness, the limes containing 4 to 5 lb. of lime and not over 1 lb. of sodium sulphide per 100 lb. of hide.

4. Drenching or bating the hides to remove surface lime and bring down the grain.

In the United States the common practice is to carry the hide through the beam-house as a whole hide, and usually also through part of the tanning process, the bellies perhaps being cropped off when struck through. In foreign countries it is usual to "round" the hide, or cut the hide into a belt bend, untrimmed shoulder and bellies, in the beam-house. The theory is that the belting bend represents the greatest value, so it should receive the best tanning material and the most careful attention. The offal represents less intrinsic value, so it can be tanned with cheaper material and by a cheaper process. Frequently one of the various rapid-tanning processes is used on the offal, and it is not uncommon to finish the tannage of the bellies by drumming with strong liquors.

As offal is not belt leather it will be given no further consideration.

**Tanning agents.**—In selecting the tanning agent for producing belting leather, the basic material should be chestnut-oak wood extract. There is no other material that has so many merits, or which will produce a leather having so many of the best qualities sought. It gives a good grain, deposits enough bloom and filling matter in the fibers of the leather to make a solid, firm leather, which is resistant to water to a considerable degree, although its tendency is possibly toward too little pliability.

On account of the bloom and filling matter deposited, the leather made with chestnut-oak wood is sufficiently solid to have little stretch and yet be elastic. The tannin of chestnut-oak wood is of the pyrogallol group, and hence gives a durable leather and one calculated to be reasonably indifferent to external conditions. The best chestnut-oak wood is one of the cheapest tanning materials per unit of tannin on the market at present. It is not only cheap, but it is practically inexhaustible, in view of the fact that it requires only 20 years for a chestnut tree to grow to a size at which it may be cut. This wood, however, is inclined to produce a rather harsh leather. Chestnut liquors develop little acid, and unless artificially acidified by the addition of acid, are inclined to make a rather thin leather. It is desirable to combine with the chestnut-oak wood some material which will develop natural acidity in the yard, obviating the necessity of artificial acidifying, and which will modify the harshness of the tannage somewhat. In myrabolan is a material which well supplements chestnut wood. It gives a mellow tannage, and will modify the harshness of the chestnut-oak wood liquors in the early stages. It is perhaps the best of the acid-producing materials, and will develop enough acid in the liquors so that with the aid of the little we get from the chestnut-oak wood it will be unnecessary to resort to artificial acidifying. Myrabolan is also a pyrogallol tannin, and so makes a permanent leather. It will brighten and lighten the color of the leather,

and the color will be little affected by sunlight. The deficiencies of the myrabolan are offset by the qualities of the chestnut-oak wood. Myrabolan, used alone, produces a light weight, somewhat spongy leather, which tans slowly, We have in chestnut-oak wood and myrabolan, then, a couple in which the qualities are complementary; what one lacks the other supplies. The chestnut-oak wood comes much nearer itself to producing the sort of leather we desire than the myrabolan does, and the mixture used will certainly not be one of 50: 50; but merely enough of the myrabolan to give the acidity and mellowness needed. In fact, probably the myrabolan will not be introduced into liquors except for the early stages of the tanning where the acid is particularly needed for plumping, and for the mellowness of liquor to prevent drawing and harshness of the grain.

Another material that might be used in place of the myrabolan, and with even better results, is algarobilla. The supply of this material is, however, so uncertain that it is difficult to rely upon it. If, as is best, myrabolan is used only in the earlier stages of the tanning process, it will be desirable to mix with the chestnut-oak wood in the latter liquors of the tanning process some material to assist at that stage. For this purpose a catechol tannin should be used, either hemlock or oak bark, preferably the latter. Of foreign materials, either mallet (from Australia) or mimosa could be used, preferably the former. An ideal tannage would consist of chestnut-oak wood extract as the basic material. To this should be added oak bark in the later stages, working the liquors down through the yard and adding some myrabolan or algarobilla to them in the early stages of the tanning process. The chestnut-oak wood would constitute more than 50 per cent of the tanning material throughout the process, but the exact proportion used would be governed by the character of the leather as it came along; as with the combination chosen, the proportions could be modified to remedy almost any deficiency in the leather, and to vary its qualities within fairly wide limits. This is one reason why a combination is so much superior to a single

material; it is much more elastic and yields a much higher-grade product.

Having selected the tanning materials to be used, and having selected them with the idea of making a leather which shall have all the qualities mentioned as being so desirable in belting, the next step is to see how to use the materials, and produce the best results in the shortest time and most economically.

**Practical considerations.**—Without going into the theory of the tanning process, suffice it to say that the underlying principles, according to which leather is successfully made, are that the tannage shall be started in liquors weak in tannin, usually liquors through which many hides have previously passed, and then be gradually transferred to stronger and fresher liquors, so that the last liquor from which they are taken is the strongest of all and freshly made. The tannin acid, and non-tannin constituents of the liquors must be so proportioned throughout that the hide acquires the proper condition of plumpness, retains that property, and tans steadily and thoroughly.

The tannin penetrates the hide by diffusion, and as the rate of penetration depends on the difference in concentration of the liquor in the hide compared with that outside, it is apparent that the hides should be placed in liquors of successively greater concentration. If, however, the increase in concentration is too rapid, the tanning may be rapid but incomplete, in some cases even to the extent that the interior will not tan at all. Another probable defect from too rapid increase of concentration is wrinkled or pipey grain. Difficulties of this sort are most likely to occur when tannins of the astringent type, such as quebracho and mimosa, are employed. The difficulty occurs most commonly in the early stages of the tanning process before the hide is struck through, as, after it is once struck through, it is little susceptible to damage from too rapid strengthening of liquors. The more mellow the early liquors the less likelihood there is of drawing the grain or case-hardening the leather. Inasmuch as old

liquors are more mellow than new, both from having the more astringent tannins sapped from them and from their lower purity due to the increased percentage of non-tannin matters, it is almost general practice to top off with strong new liquors and work these liquors down through the yard: that is, the greener the hide the older the liquor it gets until the hide from the beam-house is entered in the oldest and weakest liquor. To increase the mellowness of the early liquors still further, the use of myrabolan has been advocated at this stage, which of itself is a very mild tanning material. The acid and tannin content of the early liquors must be carefully balanced, as too little acid will make a thin, soft leather; while too much will make an over-plump leather, with cracky grain, inclined to brittleness, also probably poor in color. Too much acidity and too much plumpness also result in slowing up the tanning process. A certain excess of acid in the early liquors is necessary not merely to open up and plump the hide, but also to remove the lime which remains from the beam-house processes. If the hide is prepared for tanning with a 3 to 6-day liming and sufficient bating to remove surface lime only, it will enter the liquor in a fairly plump condition. The surface being free from lime, it will take a clear, bright color and begin to tan. The acid will diffuse into the hide more rapidly than the tannin, and will neutralize the excess of lime. The hide, as the lime is neutralized, loses its plumpness and gradually begins to fall back or grow soft. This effect becomes more marked as the hide is moved ahead into liquors stronger both in tannin and acid, until at the end of a week or ten days it is completely down and like a rag. In some plants the tendency is to remove all of the lime before entering the yard, and then use purer and stronger liquor from the start. A hide then takes on plumpness, but this time an acid plumpness; and as it progresses in the tanning process it becomes more and more plump and solid, until it has reached the particular condition of plumpness that will yield leather of the firmness and pliability sought. Ability to judge when this condition has been

reached and to secure more or less plumpness is what makes the tanner. Inasmuch as the same apparent result may follow from a variety of causes, the aid the chemist can give the tanner is by no means inconsiderable, as it will often enable the tanner to throw out various hypotheses from the list of possibilities. Often, too, chemical analyses may detect a change in the composition of the liquors before the effect on the hide has become apparent, and so enable the tanner to adjust his proportions to the correct balance before the leather has gone off. Inasmuch as the lime in the hides neutralizes the acid of the liquor, the earliest liquors will naturally be lower in acid than the later. The normal variation of the acidity, however, would be for the new liquors to be lowest in acid, and the acidity to increase steadily to a maximum from fermenting action as the liquors age. We find, therefore, in practice, a combination of these two results, that is, the sapped or spent liquors are lowest in acid from lime neutralization, the acidity increases as treatment progresses until a maximum is reached where the effect of the lime is lost and the result of the fermenting action is greatest, the acidity from then on decreasing again. Of course the tannin has steadily increased in the liquors, and also the purity.

As an example, the tail liquor might have an acidity of 0.3 to 0.4 per cent reckoned as acetic, a tannin content of 0.2 to 0.3 per cent, and a purity of say 10 per cent; that is, the non-tannin constituents would make up 10 times as much of the total solid as the tannin. With a liquor such as this at the bottom end of the yard, the tannin strength would steadily increase as well as the purity and acid, until a maximum acidity of perhaps 0.7 to 0.8 per cent is reached in a liquor containing 2 to 3 per cent tannin, and of a purity in the neighborhood of 30 per cent. From this point on the acidity will gradually decrease and the tannin increase, together with the purity. The last liquors given the hides will be perhaps 50 to 60° bk. and contain 8 to 9 per cent tannin. The strength of the final layer liquors will depend somewhat on how much the hide has been plumped, and on the beam-house conditions.

If the hide was rather strongly plumped, or too long in strong liquors it will likely produce a leather entirely too solid for belting purposes. Both treatments make a tender leather, lacking in tensile strength, and likely to crack on the surface and break after comparatively short usage; also a leather likely to tear at the lace-holes if put together with lacing.

**Tanning of belting leather.**—The hides, as they come from the beam-house, should be flat and free from wrinkles, folds, or marks of any kind. In order that they may not acquire folds or wrinkles during the early stages of the tanning process, it is essential that they be put in the liquor with a flat surface, or at least one with no sharp bends to the action of the tan liquor. Each hide, morever, must have sufficient room to prevent its coming in contact with another hide. Where two hides touch, a kiss spot is found; that is, the tan liquor does not come in contact with the hide at this spot and it fails to color. This is likely to result in a final uneven coloring, for unless the hides take the color evenly at the start, it is almost impossible to prevent the hide from showing a somewhat mottled appearance when finished.

*Rockers.*—To give the hide an even color and start the tannage uniformly, the best practice is to commence in rockers. The hides from the beam-house are laid out flat and nailed to a stick at the butt end, so that when the stick is lifted by its two ends, the hide hangs from it head down vertically. The sticks are then put in a frame which is so supported in a vat that it can be rocked up and down and the hides with it. If whole hides are being tanned, the vats must be sufficiently deep to allow the hide to hang down straight; but if only belting bends or butts, shallower vats may be used. Occasionally the hides are hung over sticks, but this is not good practice, as it often leaves a thin place in the leather, and usually a pipey grain where it came in contact with the stick.

The rockers are best worked in a series of say 10 vats, called a "round" because they are arranged in a group with no head or tail, and because each vat in rotation becomes the head of the round. One vat is emptied of the hides longest

in the round, and one filled with green hides from the beam-house each day. The vat full of oldest liquor is emptied into the sewer or returned to the leaches each day, and a vat is filled from the handlers each day. The cycle of a round may be made in either one of two ways: either the liquor may be pumped down or the hides are moved ahead. In the first method, the head pit from which the hides are taken today becomes the tail pit; yesterday's tail pit liquor is run to the sewer, and all the liquors are pumped to the pit next but one below in the round, the new head pit being filled with liquor from the handlers as mentioned above. In the second method, one pit is always empty of hides and full of new liquor from the handlers; but instead of moving the liquors, the hides are moved two pits ahead each day. As will be seen, the hides stay about 10 days in the rockers.

*Handlers.*—The hides then go to handlers or suspenders, which differ mechanically from rockers only in that hides are hung at rest. The handler round is usually larger than the rocker, but even though it contains only the same number of vats, the hides stay in it longer, generally about 20 days. The principle on which it is run is the same as for the rockers. Occasionally, instead of being run as a round, the handlers are run on a straightaway, the hides being moved ahead and the liquor pressed down; that is the vats communicate with each other so that if liquor is run into the head vat, some of the old liquor in this vat is pressed down into the next below, which in turn transfers some of its contents to the one below it, and so on down the line. Enough liquor is removed from the tail pit of the handler section to make room for what is run in at the head.

Instead of using rockers and handlers, the hides are sometimes rocked throughout the early stages up to the time when they are laid away. This has some advantages, and undoubtedly hastens the tanning process; in fact, one of the quickest tannages is dependent for its success on the rocking of the hides until the tannage is complete. For making belting leather, however, any straight suspension process is not desir-

able, as it is practically impossible to hang the hides so that they will not bag and draw somewhat into lengthwise wrinkles from their own weight. The quantity of wrinkled and baggy leather obtained by a straight suspension process is too great to warrant its use. The head liquor for the handler section is one of the oldest liquors from the yard proper, or the layaways to which has been added some fresh myrabolan liquor, in order that the necessary acidity may be developed in the handler and rocker liquors, and the liquors so mellowed. The liquors are worked down through the handlers, going then to the rockers, and finally to the sewer.

*Layaways.*—At the end of 30 days in rockers and handlers the hides are fairly well struck, the color is set, and they are fairly well fixed in their condition of plumpness. As they hung on the sticks they assumed their most natural position, bellying out here and in there, and not at all resembling the flat piece of leather which it is desired to make. However, had the hides been piled down in these early stages, or had they been pressed or pounded to remove wrinkles and bagginess, the plumpness would have been squeezed out, probably never to return. This would have been serious to both the yield and quality of the leather; flatness having been a rather minor issue to this point, attention having been fixed on securing color, uniform tanning, and the right degree of plumpness. At the end of the handler stage, however, the hides are sufficiently well set so that they may be piled down and flattened out moderately without undue loss of plumpness. If the flattening process is deferred too long, the wrinkles become so fixed that further remedies can only modify and not eradicate them. At this stage, therefore, the hides go to the layaways. These are vats large enough to permit the hide being spread out flat. They are laid down with a layer of tan bark or some inert material between each successive hide so that the liquor with which the vat is filled may come in contact with all parts of the hide. In the early days of vat tanning, when only what would be now called very weak liquors were obtainable, the layer of tan bark between the hides

was thick, and was used as much to supply tannin as to separate the hides. With the use of the present-day strong liquor, bark has become unnecessary as a source of tannin, and it is used merely to keep the hides apart and let the liquor get at them. This is not always true in sole-leather tannage, where valonia and similar materials are used for dusting. The early layers are for a fairly short time, and gradually increase in length and strength of liquor as the hides become more thoroughly tanned. A 100-day layaway series, for instance, would run 3, 5, 7, 9, 12, 16, 21, 27 days per layer, the pack being hoisted at the end of each period and laid away in a different and stronger liquor. Some tanners prefer to use a fewer number of layers, allowing the pack to remain in each layer for a longer period. At each hoisting the hides are very carefully pulled and stretched, and piled so that all wrinkles and bagginess, hip pockets, etc., will be flattened out, and the hide so far as possible put in such a condition of flatness, that when laid on a level floor it will touch at all points.

The last four or five, possibly six, liquors are fresh leach-house liquors; the earlier ones are those from which one or more packs have been drawn, so that they have mellowed and gained in acidity. These liquors are gradually worked down through the yard, through the handlers and rockers to the sewer. All the layaway liquors are not so worked down and out, some being returned to the leach-house to be strengthened and freshened; and, as previously described, the liquor run to the handlers is strengthened by fresh material, notably myrabolan liquor, to develop acid. In some tannages other materials are frequently added at this stage to secure some special color, mellowness, or other quality. The strength of these layer liquors depends on the tannage desired, but in general for belt leather the strongest liquor used would not run over 40 to 60° bk. Not many years ago, a 45° liquor would have been regarded as too strong, but with a better knowledge of the tanning process, and the growth of the use of extracts, liquors as high as 120° bk. are not at all uncommon, though not suited for making belting leather. As de-

scribed, the tanning process has required 130 days, an average time, but both longer and shorter being in use.

*Bleaching.*—It is generally held that tanned hide must be allowed to dry before being curried, in order to "set" the tannage. It is therefore common practice, whether the leather is tanned in the same factory where it is to be curried and made into belting, or whether it is tanned to be sold in the rough as a market butt, to give it a preliminary crude finish such as is seen on ordinary rough leather. This finish consists of washing, bleaching, oiling, and drying. Inasmuch as rough belting butts are sold by the pound, the usual tannery washing is the least that will conduce to a satisfactory appearance, and enable the leather to undergo the usual physical examination to which buyers subject it. Of course, when the leather is produced for local consumption, the washing at this stage will be sufficiently thorough to obviate the need of the further washing usually given leather before the currying process. Bloom is left on leather to be sold in the rough, but this must be scoured off before the currying is begun or as a part of the currying process. Briefly, the washing consists of soaking in water at 110 to 120° F., or warm weak liquor, and brushing off the surface dirt with a hand brush or by machine. Some tanners use an old weak sour liquor for soaking, claiming to get less loss of weight and some improvement of color. Color is the tanner's bugbear. If color and quality were synonymous, there would be some excuse for the stress laid on the former, but frequently leather of good color is poorest in quality, hence the tanner feels compelled to make his leather present as attractive an appearance as possible. Good looks is the only excuse for bleaching, and when one considers the damage—both present and future—which the leather suffers in the bleaching process, it will be seen that this quality is dearly bought. The bleaching of the leather is usually accomplished by soaking or wheeling the leather in a bath of sal-soda or borax, and rinsing, and placing it in a bath of some dilute acid—generally sulphuric or oxalic. After this bath the leather is thoroughly rinsed in clear water to remove

the acid. Unfortunately, the total removal of the acid is very difficult, and some remains in the leather. As sulphuric acid acts destructively on all organic material as long as it is present in a free state, a gradual deterioration—rotting of the fiber—is bound to occur in leather containing any of this free acid. A combined washing and bleaching process, which seems less objectionable than many of those in use, is to soak the hides in a liquor made from one of the heavily sulphited extracts. In fact, extracts of this type are on the market under the name of bleaching extracts, and give fairly satisfactory results. If, however, the hides are properly prepared in the beam-house, and the liquors rightly proportioned, there is no reason why leather cannot be made, which, after careful washing, will give a sufficiently good color without bleaching.

*Oiling.*—After washing and bleaching comes oiling, which consists in covering the wet leather all over with a heavy coating of Newfoundland cod-liver oil. After oiling, the leather is ordinarily piled-down over night to give the oil a chance to strike in somewhat, and is then hung to dry on hooks or clamps fastened to the butt end.

*Drying.*—This process demands careful attention if best results as regards color, flexible grain, etc., are to be secured. It was a rather uncertain process as far as results were concerned when the leather had to be dried under ordinary atmospheric conditions, but in these days of steam heat and ventilating fans there is no real reason at all for failure to secure as certain and regular results in the drying as in any other part of the leather-making process. The essentials of successful drying are to start the process in a cool, moist air, and increase the temperature and dryness of the air with the drying of the leather. When the leather has been dried, it may be trimmed somewhat, rough corners cut off, etc., and is then ready for the market.

**Currying.**—While most belt-makers probably do not tan the leather they use for making into belting, they nearly all curry the leather. They buy market butts in the rough, curry

them, and make them into belting. Currying may be defined as introducing grease into leather and giving it such a finish as will best adapt it to the purposes for which it is to be used. As a matter of fact, currying, if properly performed, is really making a combination-tanned leather out of the oak leather by giving the latter a supplementary oil or fat tannage. In order that the fat may produce this result it must be deposited on the minute fibrils which make up the fiber bundles constituting the leather. The fibrils, having already been separated by the vegetable tanning process, the fat may easily be deposited on them; but an essential condition for the successful deposition of the fat is that it be introduced into the leather while the stock is wet. As the water dries out from between the fibrils, the fat replaces it and brings about the secondary oil tannage, which renders the leather more pliable, more resistant, and permanent, and of increased tensile strength. Inasmuch as the grease is introduced into the leather when it is wet, the first step in the currying process would seem to be to wet-back the leather.

The wetting-back of the leather is, however, not ordinarily done merely as a preliminary operation to putting the grease into the leather, but is a clearing process intended to remove superfluous tannin, bloom, etc. As the washing which the rough leather usually receives at the tannery is as little as is consistent with a satisfactory appearance, the belt manufacturer finds that it improves the quality of his leather to remove some of the excess tannin left in by the tanner and replace it with grease. He therefore gives the leather a rather thorough washing, its completeness depending on the currier's previous experience with the leather, or his judgment of how much is needed.

*Scouring.*—If the tannage be inclined to excessive solidity and firmness, the leather will be soaked to soften it somewhat and then drummed with warm water. This treatment will last from 10 to 30 minutes, perhaps with no change of water, but probably with a constant stream of warm water entering the wheel; in extreme cases, the leather may be drummed in

a weak solution of borax, then in clean warm water. The drumming is ordinarily followed by a scouring process, needed particularly in the case of leathers with much bloom. This scouring is sometimes done on a Vaughn machine, a stream of water being run on the revolving roll and the leather; but it is perhaps done more successfully on a Fitz-Henry machine. A stream of water is run on the part of the leather worked on by the stones of the Fitz-Henry machine, and the movement of the stones under these conditions scours the leather satisfactorily. If the tannage is lighter, it may be sufficient

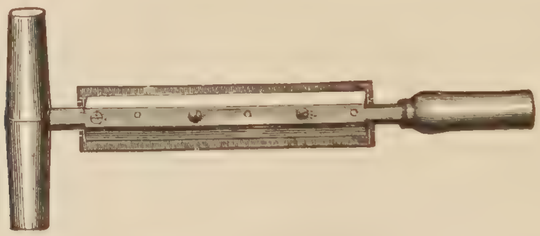

**Figure 87.—Currier's knife.**

merely to soak the hides and work them out on a Vaughn or Fitz-Henry; or even—if the leather carries little bloom—after the soaking, merely brush the leather by hand or machine.

The belt butt, usually after the washing, but sometimes before, is cut into a belt bend and shoulder. While the best part of the shoulder may sometimes be used for a cheap quality of belting, our interest is in the belt bend; but the process of currying the shoulder for belting is similar to that for currying the belt bend, save that more and somewhat different treatment is required to work out wrinkles as much as possible. The belt bend is at this stage cut into three pieces—a center and two sides—the divisional cuts being made parallel to the backbone and at equal distances from it on either side. There is a growing tendency to finish and stretch belt leather in the whole bend rather than in center and sides.

*Skiving.*—This is the removal of superfluous flesh, etc., from the flesh side of the leather. It used to be done almost entirely over the beam with a knife with a turned edge (fig-

ure 87), but this is now done by the belt-knife splitting machine. Still another method of skiving, which is largely used at present, is by the whitening machine (figure 88). Whitening is done at a later stage, but at whatever stage performed its object is to give a clean, smooth back to the leather with no superfluous flesh. If, for instance, the leather is

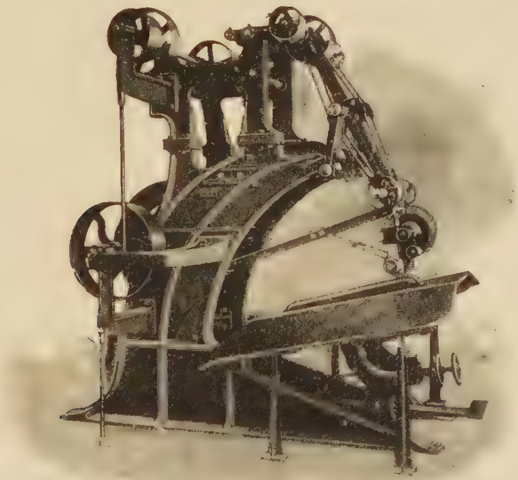

**Figure 88.—Whitening machine, used for cleaning-up flesh side of various kinds of leather.**

to be used for a double belt, that is, one made of two thicknesses of leather cemented together flesh-to-flesh, it would not be possible to cement the leather so that it would hang together under the conditions of service if any loose or superfluous flesh remained on the leather.

*Hand stuffing.*—The next process the leather is subjected to is dependent upon the particular mode of stuffing to be employed, that is, the way in which grease shall be put into the leather. There are three methods in use for stuffing belting leather, namely, hand stuffing, wheel stuffing, and hot stuffing. The first is the oldest method, and is still preferred by many manufacturers. The leather, after skiving, is damped back and piled down to even up and temper, that is, before applying the stuffing it is desirable that the leather should be in

as uniform a condition of wetness all over as can be attained. In this case, the grease will penetrate more evenly, and yields a much more uniform and satisfactory piece of leather. The currier therefore wets the leather where it seems dry and then piles it down so that parts of the leather having too much moisture will give up some to the dryer parts, and vice versa. After tempering, the leather is set, usually either by hand or on a Vaughn machine. If by hand, the leather is spread out on a table and carefully worked out by a slicker until it lies perfectly flat on the table with the edges as straight as possible and the grain smooth. If by a Vaughn machine, it is gone over several times with the roll until it is as flat and smooth as possible. After setting, it is given the grease or stuffing. This is applied usually to the flesh side alone, the grain side getting a coat of refined Newfoundland cod-liver oil. There is little variation in the composition of the hand-stuffing of dubbin used in different factories. It is generally made by melting together 2 parts of oil and 5 parts of tallow, if the tallow be soft, or 1 part of oil and 4 parts tallow if it be hard. These formulas are varied slightly according to the season of the year, more oil and therefore a softer dubbin being used in cold weather and the reverse in warm. After melting, the mixture is stirred constantly while cooling so as to produce a smooth salve-like, homogeneous mass. This dubbin is applied with a swab to the flesh of the leather so that it makes a smooth, even coating, the thickness depending on the currier's knowledge of how much grease the leather will absorb, and not be discolored or look greasy. Only the oily constituents of the dubbin enter the leather, the harder components of the tallow, stearine, and palmitin being left as a white coat on the surface. After the leather has been given its coating of grease, it is hung in a moderately warm room with a good circulation of air, and allowed to dry. If too much heat is applied the leather becomes black and greasy, the grease not penetrating into the fibrils; but if too little heat, drying requires an excessively long time and the leather is likely to mildew. When

properly carried out, the oily portions of the dubbin enter the leather as it dries, giving it a rich mellow feeling, and leaving it a good color. When the leather is dry, nothing but a dry white scale showing no oiliness should be left on the back. The leather is now taken down, wet-back once more, and piled-down, and is then ready to stretch.

*Wheel stuffing.*—The leather is washed and skived as in the hand-stuffing process, but the division of the belt bend into a center and sides is usually deferred until later. After skiving, the bend is wet-back and piled-down to temper. For wheel stuffing, this wetting-back is a most important operation, and the success or failure of this treatment depends more on the preparation of the leather than on anything else. The wetting is usually entrusted to one man who makes a specialty of that work, and he must be an artisan of rather more than ordinary judgment. For wheel stuffing, the leather must not be wet uniformly, but the softer and spongier parts of the leather must be distinctly wetter than the firmer parts, otherwise they absorb so much more grease that they appear very black and greasy in the finished leather. The usual test to find out whether leather is in proper condition for stuffing is to bend it over and see if this forces out water in fine drops; but evidently there will be a difference in behavior between the softer and firmer parts of the leather, and the precise action can be learned only by experience.

The leather which has been wet-back is usually allowed to lie in a pile, covered with wet bags or protected in some similar way, until it begins to heat up by fermenting action. It is then touched up by the man at the wheel, the spots that seem at all dry being given a little more water, and thrown into the wheel as quickly as possible to get the benefit of the heat in the leather. The old-time wheels were simply heated by running in live steam before the leather was put in, and the heat retained by the wheel depended upon to keep the leather and grease warm. The better modern practice is to use a wheel connected through the two hollow trunnions with a fan and steam coil, so that hot air can be run in and out

of the wheel throughout the drumming process. The wheel contains shelves or pins on the inside, so that the leather is carried up by the wheel as it revolves until it is no longer held, when it drops back to the bottom of the wheel to be picked up once more. The warm leather having been put into the wheel through a door in the side or rim, the hot melted grease is added, the door closed, and the wheel started. The temperature of the wheel inside is kept at about 120° F. The stuffing grease used in the wheel is harder and less oily than that used for hand stuffing. If of tallow and cod oil, a much greater excess of tallow is used, and frequently oleo-stearine is added to the mixture to produce a still harder mixture. For instance, one formula used for belt leather consists of 9 parts good tallow to 1 part refined cod oil; another and harder, 75 parts tallow, 9 parts stearine, and 16 parts cod oil. As in hand stuffing, the formula used is varied in accordance with the season of year and the known capacity of the leather for carrying grease. An average leather can carry 12 per cent of grease similar to the above mixtures, calculated on the wet weight of the leather as prepared for stuffing. It will usually require about an hour to work this quantity of grease into the leather. The rolling, tumbling, and pounding given the leather in the wheel gradually works the grease in among the fibers of the leather, but it probably is not really deposited on the fibrils themselves until the leather dries. During the last part of the drumming in the wheel, the door of the machine is frequently removed to cool the leather somewhat and set the grease, and as the leather is finally removed from the wheel it is piled down for at least 24 hours, being turned over during this time to prevent excessive heating, in order to give the grease still further opportunity to fix itself permanently in the leather.

If this were not done, far too much of the grease would be worked out of the leather during the various setting processes which now follow. The wheel-stuffed leather, which was carried along as a belt bend, is usually set on a Fitz-Henry or Turner serial table machine (figure 89), though it

is sometimes still set by hand. The former, from its construction, gives results much more nearly approaching hand setting; in fact, it is a very interesting sight to watch an experienced operator take a baggy bend and gradually work out the bag until the bend lies smooth and flat on the table, a procedure often requiring considerable skill. The

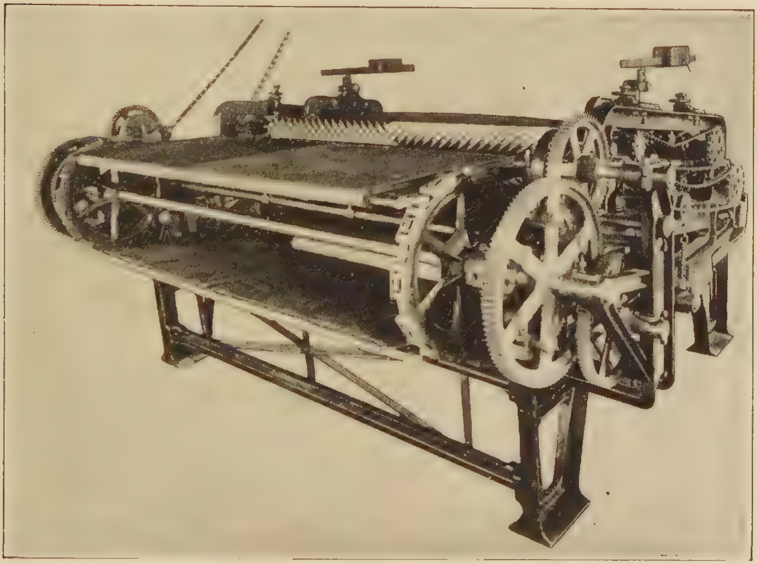

**Figure 89.—Serial table setting-out machine.**

Turner machine is very simple, and requires no special skill to operate. The bends are spread over the edge of a moving table which passes between revolving rolls. These rolls press the leather down, spread and flatten it, and set it out fairly well, if the leather was in reasonably good condition to start with, that is, fairly flat and not too hard and heavy. In the case of a really bad bend, however, hand-setting or the Fitz-Henry machine must be resorted to. The great advantage of the Turner machine is in the increased amount of work it can do. After the belt bend has been set out it is cut into a center and sides, if desired, or carried through as a whole bend, and is worked out still further on the Vaughn machine

to give a smooth grain free from wrinkles and make a more compact piece of leather; then oiled on the grain, and is ready for the stretching process.

*Hot stuffing.*—There is one more method, namely, the so-called hot stuffing. It is rather curious that if very hot grease be put on a piece of leather which contains any appreciable amount of moisture, it will burn it, making it brittle and of no strength. If, however, this same hot grease be applied to an absolutely dry piece of leather, it exerts no harmful effect. The hot-stuffing method then consists in placing the belt bends in a dry room where they are heated until all moisture has evaporated, and either laying them on a table and pouring hot grease over the flesh or grain, or both; spreading it by a brush so long as it is absorbed by the leather, or actually dipping the whole bend into a tank of melted grease, and allowing it to remain until it has absorbed all the grease possible. In either case the grease may be 200° F. or over In the second case, the leather, after removal from the tank, is hung in a hot room to drip and permit surface grease to melt off, after which it is thrown into cold water. The bends piled on the table are thrown into cold water as soon as filled.

The grease put into the leather in this way does not combine with the leather, coating the fibers and bringing about a beneficial grease tannage, but merely serves as a filler. Before the leather filled with grease by this process can be said to be really stuffed and curried, a way must be found to make the grease come into intimate contact with the fibrils of the leather. This is accomplished by wetting the leather and allowing it to dry, when, just as in the hand and wheel-stuffing processes, the grease follows the water into the inmost fibrils of the leather and brings about the grease tannage. The hot-stuffed leather, being saturated with the grease, is not readily wet-back, consequently simple soaking in water will not suffice. The leather is therefore put in a wheel and drummed with water until it has become soft and wet through. This is really a drum-stuffing process reversed. In the one

case, wet leather is put in and drummed in grease; in the other, greasy leather is put in and drummed in water. At the end of the drumming process the leather must be put through some sort of cleaning process to remove the grease from the surface and so yield a product of good appearance. The hot-stuffed leather, stuffed on the table by having hot grease spread on the flesh side alone, may be brought through in a condition where the grain is clear and free from grease and so need no bleaching; but this is doubtful policy, as it may have the grain side lacking in grease and likely to finish harsh and dry. There are a large number of bleaching processes in use, some using the regular soda and acid bleach, which is likely to be less harmful at this stage on account of the considerable amount of grease in the leather. Some makers use a little borax, soda, or soap to cut surface grease. In some cases drumming with sumac leaves is found to work satisfactorily, and this latter method would seem to have less objectionable features than any of the others. After the wheeling and bleaching processes, the belt bend is handled the same as the belt bend in the drum-stuffing process. It is piled-down, set, cut into center and sides, worked on a Vaughn machine, oiled on the grain, and stretched.

There are advantages and disadvantages connected with each mode of stuffing. For instance, it is impossible to overload the leather with grease by the hand-stuffing process; but on the other hand, it is impossible to put into the leather any of the harder greases which give leather a peculiarly mellow and substantial feel, as well as making it more permanent and resistant.

*Stretching.*—This process and finishing are the same for all the leather, whether hand, wheel, or hot-stuffed. The idea underlying the operation is that leather, being a fibrous material, will, when subjected to stress, "give" more or less and stretch out, becoming longer. If this stretching takes place after the leather has been made up into belting and put on a machine, the belt may soon become so loose that it will fail to drive, necessitating a shut-down until the belt

can be shortened; so the leather is stretched to remove most of the give, and that the trouble from the belt stretching on the machine may be lessened. It is not desirable that this preliminary stretching be carried to the utmost limit, as this undoubtedly weakens the leather and reduces its term of service.

The stretching process is simple, and consists in fastening

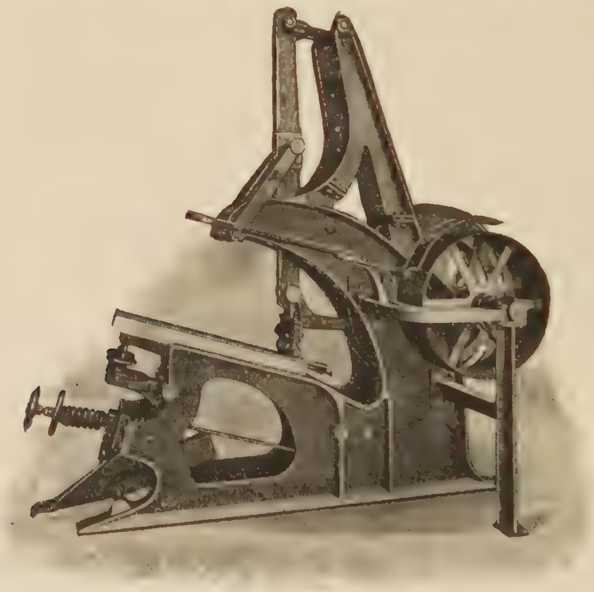

Figure 90.—Heavy rolling-jack.

the ends of the piece of leather in clamps, one of which is securely fastened at the end of a rectangular frame or board, the other of which can be moved, and by a tooth-and-dog arrangement fastened at any desired point. The frame and all is then put in a machine which grips the two clamps, and suitable mechanism pulls the free clamp slowly away from the fixed one, thereby stretching the leather. When sufficiently stretched, the dog is allowed to drop into place, and the frame removed from the machine and hung in a room where the leather can be left to dry out in the frame in its stretched condition. The leather, when removed from the frame, if it is

good leather of reasonable elasticity, springs back somewhat and loses some of the stretch given it. Moreover, on account of the unnatural condition of the fibers when dried, the leather has a rather stiff and bony feel. It is therefore worked on a heavy rolling-jack (figure 90) on the flesh side, which mellows the leather, removes the stiffness from it, and gives it pliability. If a dull finish is desired on the grain, the leather is brushed under a rotary brush; and if a glossy finish, the leather is passed on a glazing-jack, after which it is ready to be made into belting.

The question whether a leather belt should be run with the grain or flesh side next to a pulley has been much debated, and tests of the power capacity of each side were recently made by the Leather Belting Exchange at Cornell University, under the direction of R. F. Jones. The test covered two months. Five 4-inch single belts, 30 feet long, of different makes, were used; and all were thoroughly "run-in," or had reached a condition of constant capacity when the records were taken. The method was to take horsepower readings from the belts, first when running on the grain side and then on the flesh side, the power being gradually increased until about 4 per cent slip had been reached. A summary of all the tests was clearly in favor of the grain side from the standpoint of transmission. Under reasonable shop tension, the flesh side will average only 50 to 60 per cent as much power as the grain side; but the running is more uniform than the grain side.

# CHAPTER XI

## STRAP, WELTING, BAG, CASE, AUTOMOBILE, AND HARNESS LEATHER

**Strap leather.**—In this chapter only a general outline is given of the various operations, as the details involved have been already covered in previous chapters.

*Stock.*—The stock should be green-salted packer steers and cows, ranging from 50 to 70 lb.; South American frigorificos, or green-salted Chinas. These hides should be free from grubs, cuts, brands, and scars.

*Soaking.*—The trimmed stock, either as hides or sides, should be washed in the mill for 15 minutes with running water, toggled together, and then placed in the soaks, fresh water being used. After 24 hours the hides should be reeled to a second soak for another day.

*Depilating.*—For this grade of leather it is very essential to conserve as much hide substance as possible, and in order to do this, very old lime should be avoided and the time of treatment reduced to the minimum. A process which gives exceptionally good results is as follows: The soaked stock is reeled into a tail-lime liquor which has been pressed down from the head pit and to which has been added a half-pound of crystal sulphide for each side. Having established the liming process, half of the tail liquor is discharged and its place is taken with well plunged liquor from the pit above. The sulphide is added to the tail liquor. As the tail lime is discharged, fresh lime should be added to the head pit.

*Unhairing.*—The depilated hides as they come from the warm pool should be spotted on the floor for white hair, and then unhaired on either a Leidgen, Whitney, or Turner machine. They should then be fleshed on the machine, and fine-haired on the beam if necessary. The unhaired and fleshed stock should be washed in a slush-wheel or paddle.

*Bating.*—The bating should be done with oropon XX. In

using this bate, start the paddle with 12 oz. of oropon for each 100 lb. of stock, discharging a third of the liquor each day and making up with 8 oz. for each additional 100 lb. At the end of the week, completely discharge the old bate and start fresh on Monday. The temperature of the bate should be about 90° F. when the pack is entered, and the stock should be bated through before removing from paddle.

*Washing.*—The bated stock should be thrown into the paddle-wheel and washed with cold running water for half an hour.

*Rockers or stick pits.*—The washed hides should be placed on sticks, preferably using a rocker system, or some other satisfactory method of agitating the liquor. The tail liquor should stand at about 8° bk. and contain about 0.31 per cent of acid. The density of the liquor should increase gradually to 15°, and should be pressed forward each day for 20 days. It will be understood that various combinations of tanning material could be used, but it is suggested that a combination of 33 per cent hemlock, 33 per cent ordinary quebracho, 31 per cent of chestnut bark, and 2 per cent of myrabolan be employed. In order to prevent an accumulation of soluble non-tans, it is desirable to discharge at least one out of every five tail rocker liquors; the other four may be returned to the leach or extract mixer.

*Splitting.*—One of the most important factors in making strap leather is in connection with the splitting. If the stock is over-tanned before splitting, it is likely to be weak. When in proper condition the hides should be well struck, but should show yellowish through the center portion.

*Layaways.*—From the rockers or stick pits the hides are jacked and split to gage, and the grain placed in the layer. The tail-layer liquor should stand at 20° bk. and the head layer at 28°. The stock should be handled forward after 24 hours, again after 3 days, at the end of 7 days, at the end of 11 days, and removed at the end of 2 weeks. The same combination of liquor may be used as in the rockers except that the myrabolan should be eliminated. A slightly better combination,

however, consists of a mixture of 50 per cent ordinary quebracho, 25 per cent chestnut, and 25 per cent hemlock

*Bleaching.*—As it comes from the layers the stock is washed slightly and then stripped with a small amount of borax, say ½ per cent on the weight of the stock, running for 10 minutes; the borax solution is removed and the alkaline condition eliminated by running for 10 minutes with ½ per cent of sulphuric acid. It should be understood that both the borax and sulphuric acid must be very dilute.

*Re-tanning.*—To the bleached stock still in the mill, enough water is added to float it, and then 2 per cent of dry sumac is introduced. The stock is milled with the sumac for half an hour, well washed, and passed through the Quirin press.

*Stuffing.*—The well-set stock from the press is again placed in the mill and heated with hot air. When warmed through, a mixture of 3 lb. of stearine and 8 lb. of tallow for each 100 lb. of stock is melted, and at a temperature of 130° F. is added to the leather in the mill. The mill is now run for half an hour to absorb all of the fat. From the drum the stock is piled-down for several hours to set the grease.

*Setting.*—When the grease has become fixed, the stock should be dipped in cold water, and then set out on the machine, preferably the Fitz-Henry. The stock should next be piled-down over night, and then set by hand, using a dubbin of 3 parts of tallow to 1 part of cod oil on the flesh. The leather should again be piled-down over night and re-set by hand without application of dubbin.

*Tacking.*—A light coat of cod oil should finally be applied to the grain and the stock tacked.

*Whitening and snuffing.*—When dry, the sides are removed from the boards and whitened on the flesh side. They are then snuffed by hand, although some success is being obtained by using a special shaving machine and emery wheels. To the flesh side a solution of Irish moss or lissom extract should be applied, and the stock rolled on the flesh while yet damp.

*Finishing.*—To the flesh side, a solution of either dextrine,

lissom, or flaxseed liquor containing an acid yellow, should be applied. This mixture produces the russet shade. When dry, the stock should be smooth-plated and given a tallow finish on the grain. This tallow finish could consist of either pressed tallow or stearine made into an emulsion with soap. These finishes may also be purchased on the open market. When the stock is perfectly dry, it should be brushed on the machine and is ready for use. Some equipment manufacturers prefer to receive the leather before the tallow finish has been brushed, as it protects the leather during the handling through their shop. The tallow finish has an advantage over shellac finish in that it is more waterproof.

**Goodyear welting.**—The better grades of welting are made from plump hides weighing 50 to 60 lb. each, and tanned expressly for welting. Welting is also made from the shoulders of belting butts, but such leather is likely to be harsh and brittle, and not as satisfactory as that made from upper leather. The hides are limed thoroughly and bated down low to give a fine grain.

*Tannage.*—The tanning should be effected fairly slowly and the tannage should be mild to prevent drawn and rough grain from too strong liquor. Any good upper-leather tannage is suitable for welting. A combination (2 to 1) of quebracho and hemlock extracts produces good leather. The sides are suspended in weak coloring liquor for 24 hours and are then transferred to stronger liquor, which is strengthened from day to day until the sides are well struck through. Chestnut-oak wood, as well as oak and hemlock, also makes good welting leather. Leather tanned in weak liquors finishes softer and tougher than that rushed through strong liquor. The hides, when well struck with the tan, are put in the press and made ready to be split. Before being split, they are, however, cropped and the bellies sent back to be re-tanned. The backs are split 6 to 8 oz., according to the weight desired, and are then put into a drum and re-tanned with strong gambier liquor. Sumac should not be used, as it has a tendency to make the grain coarse. The next process is bleaching to remove the

stains from the splitting machine. The leather is run in the drum for 30 minutes in a solution of 6 lb. of borax in 40 gallons of water at 100° F. After this, the leather is washed in clear water to remove the borax, it is then milled in a solution of sulphuric acid, using 1 pint of acid in 40 gallons of water, and running the leather in it 20 minutes. The leather is then washed in clear water and fat-liquored.

Any good fat-liquor will do, but better results seem to be secured with the use of neat's foot oil and chip soap. The leather is fat-liquored, dried, and sammied, and set out thoroughly. A light coat of cod oil, mixed with 25 per cent of paraffin oil, is then given the grain; the leather is next turned over and struck out on the flesh, a light coat of fat-liquor being then applied to the flesh, and the leather hung up to dry. When partly dried, it is taken down and re-set with a heavy slicker, then dried and put into press. It is not rolled, nor is any finish applied. If the work is carefully done, the grain has a light, clear color which readily absorbs any stain or color that may be applied.

Rough leather of soft tannage makes good welting when finished in this manner, but it must be firm and pliable, and not harsh and brittle.

The shoulders of the hides, the butts of which are made into belting, cut from the hides before they are tanned, are largely used as welting. The shoulders, after having been tanned, are run through the splitting machine and leveled. They are then bleached with sulphuric acid after a borax bath, as described, washed with clear water, scoured, hung up to dry, and when in condition, are rolled on the sole-leather roller. A coating of oil is next given them, and they are then dried out, receiving no other finish. This shoulder welting is never as good as that made from the backs of upper stock treated in the manner previously described. An oak tannage is preferred to other tannages for shoulder welting.

**Bag and case leathers.**—The first essential in the manufacture of bag and case leathers is good hides, preferably green-salted, which are clear on the grain and free from

butcher cuts on the flesh side. When the hides have been selected, trim off the heads and shanks and put the hides into clean soft water. The best way to soak them is to suspend them in the water for 24 hours; then take them out or run off the water and fill the vat with fresh water, and soak 24 hours longer. Then split into sides, taking care to keep the backs straight. Five pounds of borax, dissolved and added to 1,000 gallons of water, helps to soften and cleanse the hides. After having been split into sides, the hides are fleshed, when they are put into clean cold water over night and the next day into the lime, which usually requires 6 or 7 days. The hides are then washed and bated by using any one of the several bating processes that have previously been described. The hides require a clean bate to prevent staining, and need to be well bated to produce a soft and clear grain. They may then be either pickled or drenched.

*Tanning.*—Hemlock and quebracho extracts used in 33 : 66 proportion make an excellent tanning process for bag and case leathers. The sides are nailed on sticks and suspended in a weak coloring liquor for 24 hours. This produces plumper leather than a paddle-vat. The sides are then put into a liquor of about 10° bk. strength, and each day the liquors are bettered until they are about 30°. When well struck through with the tan the sides are pressed and split. The grains may be re-tanned in a drum with hemlock-quebracho liquor, and then colored and finished. Tanning with hemlock and re-tanning with a combination liquor is effected as follows: The sides are tacked on sticks and hung in a 7° hemlock liquor. They are handled every day for three days, and the strength of the liquor is gradually raised to 10° and then to 12°. After being in a 12° liquor for 24 hours, the sides are put into a combination liquor made of chestnut-wood extract and quebracho extract. The strength at first is 16°; but this is gradually raised to 20°, taking 16 days to do it. The leather is next pressed and split, and the grains are then re-tanned. The re-tanning liquor should be 3 parts quebracho and 1 part gambier of about 26° strength, and the leather milled in it one

hour, then placed in piles for 24 hours, after which it is in condition to be bleached and colored.

Another good tanning process consists of two-thirds hemlock and one-third oak-bark. The hides are first colored in a sour liquor, then put into the tan liquor of 7° and handled each day, the liquor being strengthened until it is 10 or 12°. When well struck with the tan, the hides are pressed and split Re-tanning is done with either quebracho and sumac, or with quebracho and gambier. If the former is used, the liquor should be 20°, two-thirds quebracho and one-third sumac. Running the leather in this liquor for an hour accomplishes its re-tannage, after which it is ready for coloring and finishing

It is sometimes advisable to drum the sides in a solution of borax, and then in an oxalic acid liquor after they are split and before re-tanning, in order to clear and bleach them The leather is first run in a borax solution for 20 minutes and then washed, after which comes a solution of 2 lb. of oxalic acid in 15 gallons of water for 10 minutes, finally washing free of acid and re-tanning.

The usual practice, however, is to bleach leather which requires it, after it is re-tanned It should not be pressed too hard for splitting, since the more moisture there is in the grain when re-tanned the better the results will be. When leather is pressed dry for splitting, the grains should be milled in weak liquor before they are re-tanned, and this extra milling prepares them for the re-tannage More rapid and thorough penetration results by adding 1 quart of sodium bisulphite to each 6 gallons of re-tan liquor. Excellent leather is made by tanning the sides in a one-bath chrome process, then washing and re-tanning, the latter being done with quebracho and chestnut-oak extracts in the proportion of 3 parts of the former and 2 parts of the latter. The liquor should be 12° bk. at the start, strengthened to 18° the next day, and to 24° on the third day. Each night the hides should be taken out of the liquor and piled down until the next morning, and then put into the strengthened liquor. After having been re-tanned for three days, the sides are piled down until the next

day, then pressed and split. The well-washed hides, after retanning, should be stuffed with a mixture of equal parts of degras and cod oil emulsified with a soluble oil, and hung up to dry. The dry stock should then be sammied, set out, oiled off with cod oil, and tacked. On stripping, the hides should be seasoned with flaxseed liquor, rolled, and soft-

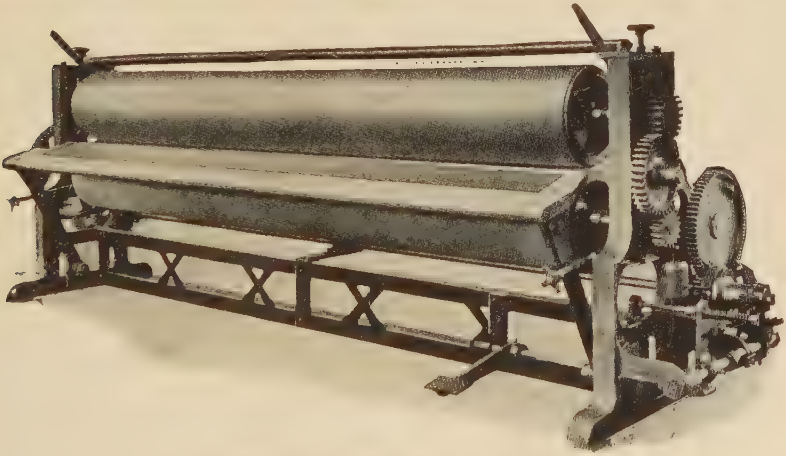

Figure 91.—Boarding machine.

boarded For soft-boarding, the machine shown in figure 91 is commonly used.

**Vegetable-tanned splits.**—The splits taken off untanned hides, that is, from hides which are split out of the lime, or out of acid pickle, or out of a pickle of aluminum sulphate and salt, can be tanned in various ways—with extract of hemlock, quebracho, gambier, and finished into inner-soling and other leather. Splits taken from limed hides are drenched with lactic acid or some other suitable de-liming material, then tacked on sticks and hung in the tan liquor and tanned wholly by suspension. Splits taken from hides full of acid and salt should be first drummed in a solution of 10 lb. of salt and 6 gallons of water for 100 lb. of splits for 20 minutes. This puts all parts of the splits into condition to take the tan liquor. The first solution into which the splits are placed is a plumping liquor made of hemlock extract, and should contain at least 0.6 per cent of lactic acid to swell the

fibers of the splits so that they will absorb the tannin. The splits should then be put into a regular bark yard and worked through stronger liquors, being handled every other day, from two to three weeks being required to tan them, according to their thickness.

Splits taken from hides pickled with aluminum sulphate and salt may be put into weak liquor or drummed therein, and then tanned in hemlock liquors of gradually increasing strength until they are fully tanned. No salt is needed in the liquors, and the sulphate or alum is washed out before the tanning is finished.

The most satisfactory way to tan splits is by suspending them in the liquor. Where this cannot be done owing to lack of vats, a paddle-wheel may be used, this being better than a drum. There is no violent pounding in the paddle, and the splits therefore finish up finer than when a drum is used. Heavy splits may be put into a 10° bk. quermos extract liquor in a paddle until they are struck through. They should then be tanned in strong hemlock bark or hemlock extract liquor until they are thoroughly filled and tanned. For light, flexible splits, some softer tannage may be used, such as quermos extract, the first liquor being 10°. The splits are then passed into stronger liquor, or the weak liquor may be strengthened. This method of tanning makes soft splits which require very little oil or fat-liquor.

Before splits which are full of alum, or aluminum sulphate and salt are put into extract or bark liquors, it is advisable to drum them in weak gambier liquor until they are softened. They should then be tanned in strong liquors, the alum and salt disappearing before the splits are ready to be finished. The splits should never be washed in water before they are tanned, or they will be flat and flabby when finished. Splits are also improved by being drummed in gambier liquor after they are tanned. This has no effect as a tannage, but it does improve the texture of the leather. Scouring and cleaning the leather is also beneficial; or the splits after they are fully tanned and drained can be rinsed in a vat of water, which will

remove any sediment. They should never be put into a drum and washed as this causes them to lose their plumpness and fall away and become thin. After they are rinsed off, they are hung on poles to dry, and when dry, they are dampened and stuffed. Rough splits for inner-soling are re-tanned with a mixture of two-thirds quebracho extract and one-third hemlock extract, then rinsed and re-tanned with sumac in a vat. They are then partly dried and stuffed, a good mixture consisting of 1 part tallow, 2 parts soap, 6 parts Irish moss, and 30 parts water. After having been stuffed, the splits are set out on a table, and a mixture of 6 parts Irish moss, 1 part starch and 2 parts soap is rubbed in on both sides with a stiff brush. They are then set out with a slicker and hung up flat to dry. A jacking completes the work. Tanners who want to increase the weight of their splits add a little grape sugar to the stuffing mixture.

Splits taken from hides tanned with hemlock, quebracho and chestnut extract in combination process can be worked into Goodyear stock by being trimmed after they are split, and re-tanned in a paddle with a combination liquor composed of quebracho and chestnut extract. They may be run a short time in a drum with a weak liquor to break up the crust caused by the belt-knife. They are then put into a 16° liquor and left in it 48 hours, and next placed in piles 48 hours; then returned to the liquor for 48 hours, the paddle being run about 2 hours in the morning and 2 hours in the afternoon. When well filled, they are left in piles for a few hours and then put into a drum with the following mixture: For 50 Goodyears, use 4 lb. of flour, 8 lb. of epsom salts, 1 gallon of cod oil, 1 gallon of degras, and 10 lb. of talc, all mixed together to a smooth paste; then add water at 85° F., to make 25 gallons. Run the splits in this solution for a half-hour and then put them into piles over night. In the morning set them out thoroughly; apply a paste made of Irish moss or lissom extract and flour, and hang them up to dry. When dry, give them a coat of Irish moss and talc on both sides, and roll hard; then dry.

*Softening and stuffing heavy splits.*—The dry splits require careful dampening and softening. A good way to do this is to wet half of them in water; then place a dry split on the floor, then a wet split on top of it, then another dry one, then another wet one until all are piled-down. Leave them there 2 or 3 days to become uniformly soft and damp, keeping them well covered. Proper dampening is the secret of soft, well-filled goods. The splits can also be dampened by being sprinkled with water or sprayed with a hose and left in covered piles until they are damp and soft; 200 lb. of dry splits should not weigh more than 260 lb. when damp.

The amount and kind of grease to be used depends upon the tannage, and must be decided by the operator. Some tannages take more grease than others, gambier and other soft tannages not requiring as much as hemlock and combination tannages. The harder the grease the more can be put in. Sometimes 100 lb. of dry splits will carry over 100 lb. of grease, 110 lb. being the maximum. The grease should be heated to 125° F., and the drum with live steam to the same temperature, before the splits are put in. Some degras may be used and a little sod oil, say 10 per cent of it, but not more, and this only when the grease is good and hard, or when stearine is used in making the stuffing. The splits, as well as the grease, having been weighed exactly, should be carefully and uniformly dampened, and the right temperature maintained during the process. A good stuffing mixture for gambier-tanned splits is made of 6 gallons of brown grease, 4 gallons of common wool grease, and 2 gallons of stearine. If the brown grease is good, use less stearine. Use from 4 to 6 quarts of sod oil to every 12 gallons of the stuffing mixture. If the splits are very hard, use a half gallon more of sod oil to each 12 gallons of stuffing. After having been stuffed, the splits are finished by being whitened, blackened with soap and lampblack, dried, trimmed, given a paste of flour, dried, rolled or glazed and covered with a size made of gum tragacanth, lissom extract, dried again, sorted, and graded.

*Stuffing for waxed splits.*—To make 100 lb. of stuffing grease, take 45 lb. of tallow, 10 lb. of wool grease, 25 lb. of stearine, and 20 lb. of paraffin wax. Dissolve the stearine and wax, add the tallow and then the wool grease. Use from 35 to 40 lb. of the stuffing to 100 lb. of dampened splits. Heat the drum to 125° F., and the grease to the same temperature. Let the drum run 20 minutes with the door closed and 10 minutes with the door open. Hang the splits up until they are well cooled off and stiff; next set them out tightly on the back and then on the face side, and hang them up to dry.

Another formula for stuffing is: Heat hard glucose to 140° F. in a suitable kettle. In another kettle place one-half wool grease, one-half brown grease, and one-third best stearine, and cook thoroughly. Use about 12 lb. of glucose with 40 lb. of combination grease, mixing just before using. The glucose gives good color and weight, but it must be used carefully and with judgment. If the splits are too wet or too dry, or of hard tannage, no stearine is necessary, good brown grease and wool grease and glucose being sufficient under such conditions. Dampening for stuffing should be done in such a manner that 300 lb. of splits take an additional weight of 35 pounds.

**Harness leather.**—Green-salted hides are generally used in the manufacture of harness leather. They are washed for 10 minutes in running water, cut into sides, and soaked for 48 hours in the pit. When thoroughly soaked they are fleshed and limed for 5 days with hydrated lime and sodium sulphide. Unhairing is most generally done on the Leidgen machine, after which the sides are bated with oropon. When well bated, the stock goes to the tail rocker containing an 8° bk. liquor with an acidity of 3 per cent The sides remain in the rockers for 8 days, the strength being gradually increased to 15°. The liquor in the handlers consists of the mixture of hemlock bark, quebracho and chestnut-wood extract in about equal proportions. On removal from the head rocker, the sides are placed in the first layer for 5 days where they meet a 21° liquor made up in the same proportion as the rocker liquor.

In the second layer the stock remains for 11 days, meeting a liquor of 22°. In the third layer, standing 23°, the sides remain for 15 days. The spent liquor from the first, second, and third layers is used for strong liquor in the head rocker. The fourth layer liquor is made up, 50 parts quebracho, 30 parts chestnut-wood extract, and 20 parts hemlock-bark extract, and stands at 20°. Here the stock remains for 25 days.

To secure more uniform treatment it is customary to use dust in the second and third layers. From the fourth layer the stock is washed and bleached, wrung out, shaved, and hung up to dry. The dry sides are sammied back with water, and when properly tempered they are ready for stuffing.

The stuffing is carried out in a drum with a hot mixture of oleostearine, degras, paraffin wax, and tallow, using 38 per cent on the weight of the stock. The sides, on being removed from the drum, are hung up to chill and set on the grain on a Fitz-Henry machine. They are again set by hand, using a dubbin of tallow and cod oil. The well-set sides are then hung up and allowed to dry thoroughly. When dry, the stock is jacked and snuffed.

A blacking of hematin and nigrosene is applied to the grain, the color being set with an iron striker. Scar paste, which consists of a mixture of glue, nigrosene, and potassium ferrocyanide, is then applied. The dry stock is now given a coat of tallow and is whitened on the flesh. It is then jacked and brushed.

**Good color on heavily stuffed leather.**—The moisture content of leathers is perhaps the most important point to watch in the production of a good color. A leather containing too much moisture absorbs the grease with difficulty, but leather which is dry absorbs the grease too readily, as already mentioned, and allows it to remain on the surface, producing a dark color. The fineness of the division of the oil also determines the color of the resulting leather. The more finely divided the oil the more likelihood there is of producing a clear color. It is for this reason that emulsions of oil have advantages over pure oils, and since degras produces one of

the best emulsions known, it is in great favor with curriers, when a light color is desired.

The nature of the greases which enter into the composition of the stuffing mixture is of first importance from the point of view of color, it being a good plan to have as large a proportion of hard grease as possible, keeping in mind the degree of suppleness desired. Solid greases which can only be introduced into the leather by the aid of heat, possess the property, during cooling, of lightening the color. The use of stearine instead of tallow may be of advantage if the leather is originally sufficiently soft, since it produces greater firmness than tallow.

In recent years, many solid mineral greases, which possess the double advantage of producing good color and of being cheap, have been put on the market. Certain of these products have the special advantage of being emulsifiable with water, thus playing the part of a solid grease in the shape of a fine emulsion. It is also possible to mix these materials with tallow or stearine in such a way as to produce greases having varying melting points, according to the degree of suppleness desired. The solid mineral greases which are emulsifiable generally have melting points somewhere about 113° F. They may be used alone or in an admixture with tallow. If used with the latter, the melting point may go down to 95° F., which is helpful for suppleness. These greases may also be mixed with stearine, or with a mixture of tallow, stearine, and moellon. By this means it is possible to obtain a much brighter color than was formerly possible by the old processes of currying, a greater quantity of grease being introduced at the same time. This is not harmful to the quality of the leather, rather beneficial. Goods thus stuffed have, in fact, a greater tendency to maintain the dry appearance of well-stuffed leather.

One of the features of the superiority of modern currying, as viewed from the final color of the leather, rests in the practicability of stuffing the leather in a drum. It will be readily understood that this treatment possesses the advantage of

increasing the fineness of the division of the grease, thus allowing it to penetrate the fibers of the leather and be assimilated more rapidly, all of which helps in the production of a satisfactory color. To this advantage may be added the fact that a considerable proportion of hard grease, at least 25 to 30 per cent of the total, can be used; and a finished leather will be produced, which, in drying, will not make apparent the amount of grease which has been incorporated.

For the drum stuffing of leather there are two common methods of procedure: the first being to apply the grease to the leather on the table, and when thus plastered, to drum it in a heated drum; the second treatment being to warm the drum, and after introducing the leather, turn it for a few minutes to warm the latter. The grease, at a suitable temperature, is then put in, and turning is continued from a half to one hour, until all the grease has been absorbed. Curriers who use the first method give it preference. A leather of good color is very easily produced by this process, but it is probable that a less quantity of grease is introduced than by the second method. If it is not desired to introduce a great quantity of grease into the leather then this first method, that is, to apply the grease on the table and drum afterwards, may be used; but it is quite probable that just as good a color may be obtained by the second method, and at the same time a larger proportion of grease be introduced. The chief reason why some curriers do not succeed with the second method is that they do not sufficiently study, before stuffing the leather, its condition as regards moisture, its proper condition in this respect being indispensable for success. If the hollow or loose parts of the leather are not sufficiently dampened at the moment the goods are put into the drum they will absorb too much grease, and too dark a color will result, while the other portions will remain insufficiently stuffed and will be of a much lighter color, a bad result.

The secret of success in direct drum stuffing rests in putting the leather into proper condition of moisture before stuffing; this work should be entrusted only to a skilled man, who can

detect at a glance the hollow part in the leather and how much moisture should be given to it. Once the leather is properly dampened, giving more to the hollow parts, it should be placed in a pile for a sufficient period for the moisture to be evenly distributed among the fibers, and then to proceed to the stuffing. With these precautions observed, the second method of manipulation will give a color just as good as the first, and in addition, it will allow a much larger proportion of grease to be introduced into the leather.

As a final precaution, the stuffing formula should contain an emulsifying agent, which will ensure a perfect emulsion of the whole; for example, soluble oil, moellon, or one of the mineral greases mentioned, which being themselves emulsifiable, impart this property to the other greases.

Certain curriers make it a practice to open the door of the drum after the absorption of the greases, and continue the turning of the drum until the greases solidify. There is, however, no marked advantage in this method. It seems preferable, as soon as the grease has been absorbed, to remove the leather and to hang it up until cold. After this, it is good practice to soak the goods in a sumac bath for one or two days until complete penetration has taken place, and finally set them out. In this way, other things being favorable, a perfectly satisfactory color will be obtained.

The stuffing of belting leather can be carried out either on the table or by immersion. There is an indispensable precaution to be taken in order to produce a good color, and that is, when stuffing is carried out by hand, to moisten the grain lightly in order to prevent the grease from penetrating through to it. Without this precaution the grease traverses and makes the surface a dark color. On the other hand, moistening the grain causes the grease to set the moment it reaches it, and thus helps to maintain the color.

There is also another method of procedure which gives good results, and that is, the grease must be appreciably hotter than the leather. On a table, which should be a little larger than the butts, are placed a certain number of pieces of felt

capable of absorbing moisture easily. These pieces should be as large as the table itself, and on top of them is placed a similar piece of felt, the whole forming a soft cushion on the table, which is kept wet. Each butt, on coming from the hot chamber, is placed grain downwards on the cushion, and the grease is applied to it in this position. The cushion, by its softness, adapts itself to the surface of the butt, and its moisture prevents the grease from penetrating to the grain, because as soon as the grease traverses the leather and reaches the moist grain, it sets. In spite of this, it is essential that the grease should be applied as rapidly as possible, as the butt must be allowed sufficient time to cool down during the process. Finally, great care must be taken that the temperature of the grease always remains the same. Immediately after this application of grease the butts are immersed either in cold water, in weak liquor, or in a sumac liquor, and left there two or three days. This obviates drumming the leather after stuffing, an operation which always causes a loss of weight. The longer the butts are allowed to lie in this liquor the greater the chance of causing the dark stains, which may have been produced on the grain, to disappear. The butts are finally rinsed in cold water and set out carefully on a table. The grain is moistened regularly with water, and a mixture of tallow and cod oil in equal parts is applied to it cold, a good natural color being thereby produced. If a lighter color is desired, less grease is given. There are other precautions that may be taken after stuffing, which help to produce a good color. In the first place, the drying after stuffing must take place very slowly.

The temperature of drying must not be too high, otherwise the grease will melt and appear on the surface. It is, however, necessary that the drying should be carried out in a sufficiently high temperature for the greases to remain soft, in order that they can be finely divided as they penetrate to the interior of the leather. The temperature most suitable must be determined by the melting point of the grease employed. In some works, time is saved by not drying out com-

pletely, but by setting out in the half-dry state. It is, however, much more preferable to dry completely and dampen back again regularly in order to set out. This precaution should especially be observed when dealing with leather stuffed by dipping. It is good practice after currying to leave the goods in the warehouse for a sufficient time for the grease to be properly assimilated in the interior of the leather. After this period the last trace of grease which remains on the grain may be removed with care by means of a fine slicker.

The process of bleaching, which contributes to the production of a regular and light color, can be carried out after tanning, either before or after stuffing. In principle, bleaching before stuffing is to be preferred. Weak solutions of oxalic acid, sulphuric acid, potassium oxalate, or sulphurous acid are used. There are also on the market products called "hydrosulphites," either under this name or under special trademarks. These materials enable one to produce an efficient bleaching in a simple manner, the solution being prepared at time of using. In spite of the superiority of bleaching before stuffing, it often happens that it is more convenient to bleach after the stuffing. A method of bleaching leather, which has been stuffed with a large quantity of grease, is as follows: The first precaution is to remove completely all excess of grease from the surface of the grain. The butts are placed in a pile for 24 hours and immersed for one minute in a bath at 77° F. containing 3 per cent of caustic soda, the leather thereby becoming very dark. It is washed in tepid water, and then placed in a cold 5 per cent solution of hydrochloric acid until it becomes light again, when it is carefully rinsed with cold water. This process must only be taken as an example. In principle, the processes of bleaching used before stuffing may be equally well used after stuffing, but to make their application successful after stuffing it is essential that every trace of grease shall be removed from the grain. This can be accomplished by means of a good washing with a soap solution, followed by careful rinsing. The ordinary process of bleaching can then be applied, and may be combined with

treatment in sumac. For belting leather, the butts, after having been washed and set out by machine on flesh and grain, are placed in a pit, together with a strong lukewarm sumac liquor, and left therein one day, being removed two or three times. The sumac may also be given in a drum for one or two hours. The butts are set out on a table with a stone slicker, carefully brushed, allowed to dry gently, and placed in a pile when half dry. Treatment in a sumac bath helps to brighten the color of harness leather also. The quantity of sumac depends upon the nature of the original tannage, but about 2 lb. per butt is an average quantity. In the manufacture of harness leather, and especially for leather that is to be stained with light colors, special precautions are sometimes taken. In the first place, only hides of particularly good color are selected. After shaving, they are drummed in a sumac bath, which has already been used once before, then set out by machine. They are then given a second sumac bath, this time one freshly prepared. The treatment with sumac does not necessarily exclude chemical treatment with oxalic acid. If the two processes are combined, the color obtained is even lighter. If the suggestions given are followed it is possible to obtain a leather which has absorbed considerable grease and is of sufficiently light color and dry appearance to satisfy the most exacting customer.

**Automobile leather.**—For automobile, carriage, and upholstering purposes, spready hides are used, so that the hide dealer or tanner taking up the stock makes his selection on spreadies. The hides used for this class of leather are usually green-salted.

In the preliminary work the hides are soaked, fleshed, limed, unhaired, and bated. They are then run in the paddle with an acid-spent tan liquor to set the grain and impart a uniform color. The hides, having been colored, are suspended by the butt in rocker frames, in which case the pits must be sufficiently deep to prevent sagging to the bottom. The rocker system for this class of stock is worked on the same principle as that described under sole leather.

*Tanning.*—The liquor commonly used in the rockers consists of a mixture of hemlock and chestnut-oak bark. The tail liquor should be very weak, stronger liquor being used as the tanning progresses. Usually from 8 to 10 days is a sufficient time for the rocker treatment, as it is only necessary to bring the hides into such a condition that they may

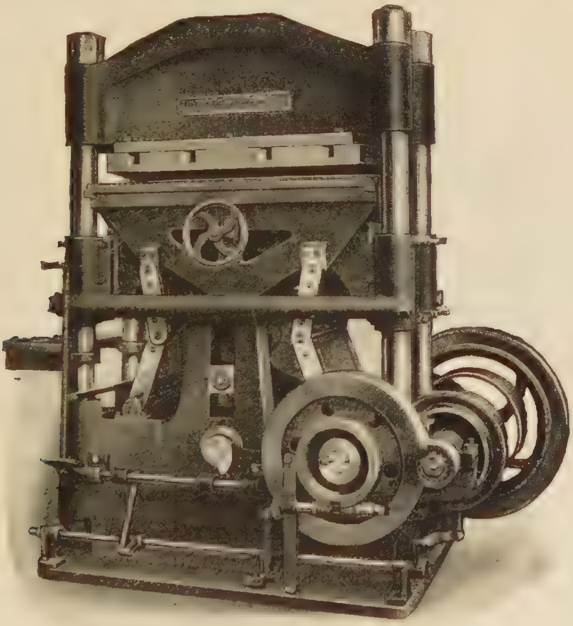

**Figure 92.—Sheridan embossing press.**

be split. The rocker liquor, of course, should be sufficiently acid to produce the necessary plumpness.

On removal from the rockers, the hides are passed through the wringer, and are then worked on the stoning-jack to remove any wrinkles and smooth out the leather. A grain split is first removed, and the remainder again split into various weights according to market demands and the judgment of the splitter. The grains split are usually re-tanned in a drum with quebracho or a mixture of quebracho and gambier. The flesh splits are, as a rule, re-tanned in the paddle, although some tanners prefer to re-tan in the pits. For re-tanning the

flesh splits gambier is very largely used, but sometimes mixed tannages are employed.

The re-tanned splits are next run in a paddle with sumac liquor, to which degras in the form of an emulsion is added. They are then set out carefully either by hand or machine and given a coat of degras and cod oil. Having been oiled, the leather is tacked closely on special frames, these being so

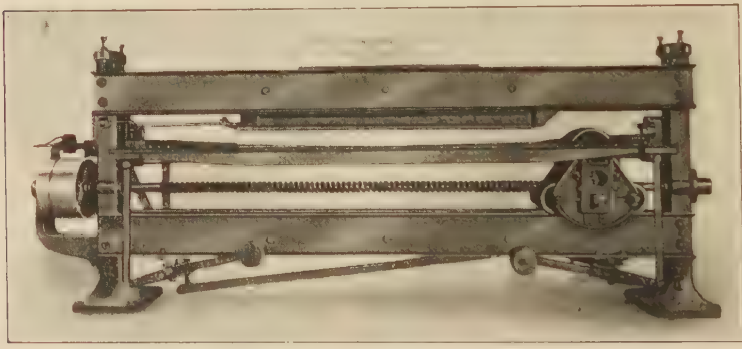

**Figure 93.—Embossing machine.**

constructed that the leather may be stretched in all directions, clamped in the extended condition, and allowed to dry.

The dry leather is removed from the frames, broken to make it soft, and after buffing is ready for the application of the finish.

*Finishing.*—The finish of this leather is usually made by boiling linseed oil with a drier and some pigment. The oil is heated over a coke or oil fire to a temperature of about 600° F., and is allowed to cool to about 350°. The fire is then extinguished, and the necessary amount of naphtha is slowly added. This produces a jelly-like mass known as "sweetmeats." The pigment, which has previously been ground in oil, is now carefully incorporated and forms what is known as the "daub."

The grains and splits, having been assorted for grades, are stretched on frames and given a heavy coat of daub. This material is applied evenly, and the excess is removed with a

slicker. The hide is then allowed to dry in the air. A second coating of the same material is applied, and the frame is placed horizontally in the drying oven in which a temperature of 120° F. is maintained. The third coat consists of plain boiled linseed, which is dried in the oven at a temperature of about 130° F. When perfectly dry, the surface is

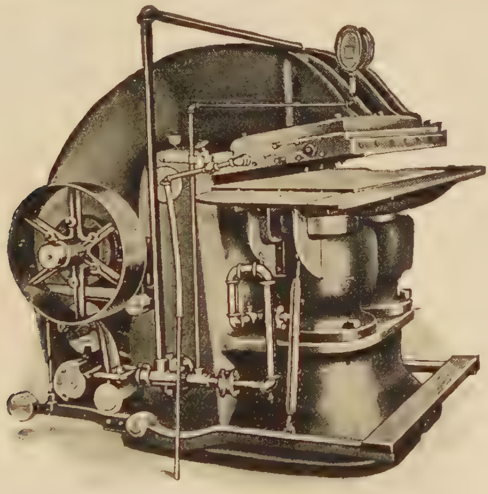

**Figure 94.—Turner hydraulic embossing and smooth-plate press.**

rubbed down with a brick of pumice stone. The number of daub coats and varnish coats varies, the brighter the finish desired the more varnish applied. After the bottom or daub coats the finishing coats are always rubbed down with pumice before application of another coat, except in the case of the last coat, which is not pumiced. After thorough drying in the oven, the frames are placed in the sun to remove the stickiness, and after sun-drying the splits are stripped and trimmed, and are ready for market.

The greater part of this kind of leather is embossed in order to produce an imitation grain. This grain may be of various designs and color according to the demands of the trade. Figures 92, 93, and 94 show three kinds of presses used for this purpose.

In place of the daub coat above mentioned, many other materials and combinations of materials are used; the most common, however, is pyroxylin.

"Spanish leather," so called, which is much used at present, is produced by tanning the hide in strong quebracho liquor which draws up the grain and gives the leather its unique appearance. In finishing this leather it is dyed to shade and then rubbed over with a pigment in oil. The excess of pigment is removed from the surface by brushing, but leaves a color in the wrinkles. The same effect, however, is more commonly produced by finishing with linseed oil daub, and then embossing the product with a Spanish grain. The color in the wrinkles is produced in the same manner as just described.

## CHAPTER XII

### PATENT LEATHER

**Patent leather.**—Any leather that carries on the surface a high-gloss varnish finish is called "patent leather." The terms japanned, enameled, and patent are synonymous, except that enameled leather is usually that in which the finish is applied to the flesh. The following description is taken largely from a lecture given by George W. Priest before the tanning and applied leather chemistry students at Pratt Institute, Brooklyn, N. Y., for which the author desires to give him full credit:

In a description of patent leather the subject should be divided into three parts, namely, (1) raw materials; (2) preparation of compositions and varnishes; and (3) application of the above.

The raw materials used in making patent-leather compositions and varnishes are: linseed oil, turpentine, naphtha, soluble cotton, amyl-acetate, lampblack, Chinese blue, Prussian blue, umber, litharge, and spirit black.

*Linseed oil.*—This material belongs to the class of oils which absorb oxygen from the air and dry to an elastic, flexible film of varnish. No other oil approaches linseed in its drying properties.

The oil is expressed from flaxseed which comes from Russia, India, South America, and the United States and Canadian Northwest. That made from the North American seed makes the strongest and most flexible varnish. Calcutta comes next, making a softer varnish, while the South American seed is poorest. Consumption of linseed in America is so great that the domestic production is too small, and supplies have to be drawn from India and Argentina.

It was formerly believed that Calcutta oil made the best

varnishes. This idea probably arose from the fact that all the Calcutta oil was expressed, made up, and tanked ready for use as soon as it came in. This tanking gave the oil an ageing which made it better. The domestic oil was expressed and sold at once. An oil kept for a long time at a moderate temperature makes a more brilliant and flexible varnish, and one which works freer.

The present great demand for linseed oil does not permit of any long storage in refiners' hands, so that oil is put on the market only a few weeks old, often only a few days. Modern methods of refining have been so perfected that a fresh refined oil is better than some of the old tanked oils.

Two classes of oil are sold to the patent leather manufacturer. One called an "aged" oil, which has received some beneficial treatment in the refinery, is used for making the "daub" or bottom coats. The treatment causes the oil to "body" more quickly so that the cooking time is shortened. This oil is of a softer nature than the varnish oils.

For the varnish coats a refined varnish oil is used, although there is no reason why the "aged" oils should not be used. Special varnishes and other patent-leather compositions are of such a heavy and viscous nature that some solvent must be mixed to thin them so that they will flow freely under a brush.

*Turpentine.*—This makes an ideal thinner as its boiling point is high enough to permit plenty of time in brushing before it evaporates. It was formerly used to thin down the varnishes so that they would flow easily, but the high price has almost prohibited its use, although some tanners still use it mixed with naphtha.

*Naphtha.*—Two grades of naphtha, motor gasoline and V. M. & P. naphtha, are used for reducing varnishes and compositions. The former dries out completely in a short time, while the latter takes more time and probably never completely evaporates. The higher boiling portions of the heavier naphthas have been known to cause serious trouble, and attention must be given to these goods to see that they ru: uniform and dry completely.

*Soluble or nitrated cotton.*—This is the non-explosive form of guncotton, which, when reduced with amyl-acetate, is used as a lacquer. Mixed with camphor it forms celluloid. Nitrated cotton makes a very tough, transparent film that cannot be used alone for producing a finish on leather, but must be mixed with some kind of oil.

For patent leather it is customary to mix the cotton with boiled oil and amyl-acetate. Such a composition is particularly adapted for small fine-grained skins like kid or coltskin. Amyl-acetate is the only practical solvent for guncotton, and gives the best results on leather. It may however be mixed with a small proportion of naphtha without precipitating the cotton from solution.

*Lampblack.*—In order to get a black foundation for the bottom coats a very fine grade of lampblack is used; this lampblack weighs about 4 lb. to the barrel.

..*Chinese blue.*—This comes in lumps or powder of an iridescent purple color. It is used as a dryer in making varnishes. Some makers use the lumps directly in the kettle; others buy the blue in powdered form; and still others powder the blue, grind it in oil, and then boil it with the varnish. Any one of these methods seems to make equally good varnish.

*Prussian blue.*—This salt, which is of nearly the same chemical composition as Chinese blue, is used ground in oil, with a little black, and mixed with the bottom coats as a pigment to give color.

*Umber.*—This is used as a dryer in the oil boiled for the bottom coats.

*Litharge.*—A lead oxide, is sometimes used with umber and sometimes replaces it. It makes a softer coating than the umber.

*Spirit black.*—This is a coal-tar color used to give color to the nitrated cotton coats.

**Boiling the oil for the daub coat.**—The bottom or daub coat acts as a filler or sizing on the leather, whether it be chrome or vegetable-tanned. In order to keep this coat from penetrating too deeply and so injuring the leather, the oil

is boiled to a very heavy, viscous mass. This requires a long time at a fairly high temperature. To assist and shorten the time, the so-called "aged" oils are commonly used, which have had some treatment that makes them cook and come to a body much quicker than a raw oil. The treatment does not in any way injure the strength and elasticity of the coatings.

The oil is boiled slowly at first with $\frac{1}{4}$ of 1 per cent of umber; the temperature is then raised gradually until it reaches 575° F. or thereabouts. This temperature is maintained by pulling the kettle on and off the fire. As soon as the temperature reaches about 350°, light vapors begin to come from the oil; these have a rather fragrant odor, but as the boiling continues the vapors become much denser and more pungent. As the oil breaks up under the heat, oxidation takes place, and large quantities of acrolein are given off, which attacks the mucous membrane acutely. To protect the oil boiler, the chimney in which the boiling is done is well ventilated so that the obnoxious and poisonous fumes are carried away.

During boiling, the oil loses about a fifth of its bulk through distillation and the breaking up of the glycerides of the oil.

In Germany, where the phenomena of oil boiling have been carefully studied, it has been found that the linolein, which is formed by oxidation at low temperatures, is more elastic and tougher than the linoxyn formed at higher temperatures.

When the oil has reached the desired consistence, which can only be judged by practice, the kettle is taken off the fire and taken about 20 feet away. The outside of the kettle is sprayed with water to put out all sparks, and the hose is turned on the fire in the boiling-house until the fire is completely extinguished.

The daub is so heavy that naphtha or other solvents will not mix with it in the cold, therefore the naphtha is put into the hot daub. This sudden addition of cold naphtha to very hot daub at once vaporizes the naphtha, which travels along the ground like a white fog. For 50 gallons of daub, 100 gallons of naphtha are generally used, about half of which

evaporates. As the lighter parts evaporate first, the heavier parts, which are slow drying, are left in the oil.

A machine patented by George Priest is in use in several plants, and by it the daub is stirred mechanically during the mixing and the naphtha is caught in a condensing dome. No naphtha is lost in this machine, so there are no fumes and no danger to the boilers. The daub made by this machine is said to be much smoother than by the old method. The machines have been in operation for over 15 years without explosion or trouble and seem to be practical.

After the naphtha has been added, the daub is stored ready for mixing, which is done by the addition of more naphtha and lampblack according to the judgment of the head mixer.

The consistence of the boilings varies from a heavy body, which will string out in silks, to one that is like heavy flour paste in body. The more open the leather to be coated the heavier should be the boilings. The second coat was formerly put on with a slicker, and was the same as the daub, but with more naphtha in it. It is now customary to make a special boiling, which, when reduced with naphtha, is thin enough to be applied with a brush. This color coat contains Prussian blue in oil.

*Varnish.*—As the varnish has to stand all the wear and tear of hard usage and weather, the greatest care is taken in selecting the oil, and in its cooking.

The driers used are Chinese blue lumps, about 3 per cent on the weight of oil. These are introduced when the oil is at about 350° F. In making varnishes, the temperatures are raised gradually and with constant stirring. Within reason, the lower the temperatures and the longer the time of cooking the stronger and more flexible is the varnish. Chemical changes take place at low temperatures which improve the oil, causing the varnishes to become more elastic and to dry quicker. The consistence of the varnishes varies with the kind and quality of the leather, and is controlled by the boiler. The varnish is usually stored 10 days before using; longer storage does not improve it enough to warrant extra time.

*Application of compositions to leather.*—After the leather has come from the de-greasers, it is stretched tightly in frames by means of metal toggles.

The consistence of the bottom coat is largely a matter of judgment. The stock daub which contains naphtha, heavy boiled sweetmeats, and lampblack, is reduced with the proper amount of naphtha in a mixing machine. This is spread evenly over the surface of the hide and well rubbed in by hand; afterwards the excess is spread off with a steel instrument called a "slicker." When properly applied, the surface should be uniformly black, free from streaks, and should stick slightly to the hand. The hide is then stood up to dry in a drying room at a low temperature. This coat is not exposed to the sunlight. If pyroxylin is used, it is reduced with amyl-acetate to give the best results, and applied with a sponge and dried in a way similar to the oil finish.

The second coat is applied on top of the daub on the following day. The hide receives a slight rubbing with pumice, and the second coat is applied with a brush. This composition contains some pigment to give color to the leather. It is well brushed in, and the hide is stood up in a drying room at a moderate temperature. If the hide is very open a third coat may be applied.

Before the varnish is put on, the hide is well stoned and carefully brushed with a wet brush to free it from all dust which may have been made by the rubbing down with the pumice. Great care is taken while varnishing. The room is well heated so that the varnish will flow freely. While a certain amount of ventilation is necessary, this is so arranged that no direct draught blows over the leather under treatment. The men work stripped from the waist up to avoid flying dust and lint from clothing. The varnish is in 15-gallon cans, this size giving the best results because it is so deep that any dirt getting in the cans settles at once to the bottom far away from the reach of the varnish brush. On hides, the varnish is usually applied with a large round brush 4 inches in diameter and with bristles 8 inches long. A brush

full is applied to the hide, and is flowed on and well brushed down to avoid streaks and ensure an even coating. The hide is then placed in a horizontal position in the oven, the distance between the hides being about 3 inches. The temperature is gradually raised to about 160° F., and the hide is left in over night. The next morning the varnished surface should be brilliant, free from dirt, and a bit tacky or soft. To overcome this, the hide is generally exposed to the sunlight all day. The combination of the ultra-violet rays in the sunlight, and the air, finish the oxidation of the varnish, so that it is soft and flexible, but will not stick if two varnished hides are laid away face to face.

A method of drying patent leather by the use of the Cooper-Hewitt mercury-arc quartz lamp has been developed by George Priest. This method has been used successfully in a number of plants. The theory is as follows:

It has been known for a long time that the ultra-violet or short wave-length rays in the sunlight produce certain chemical results. They bleach linen, discolor dyed leather and fabrics, and oxidize oils and varnishes.

It has also been known that the old form of Cooper-Hewitt lamp produced small quantities of ultra-violet light. This lamp is a long tube of glass suspended horizontally from the ceiling, which produces a peculiar and somewhat ghastly green light, but which is, of all artificial lights, least trying to the eyes, and is used wherever much night work is done requiring constant application of the eye.

It is known that the stronger the electric current the more ultra-violet light can be produced, but two things prevent the common mercury lamp from giving this result; first, ultra-violet rays will not go through ordinary glass (the other rays go through, but it acts as a screen for the violet rays); second, in increasing the strength of the electric current the glass tubes were melted.

Within the last few years the art of making transparent quartz has been perfected. Quartz transmits the ultra-violet rays, and has such a high melting point that strong electric

currents, which produce light rich in ultra-violet rays, can be used. The lamp was at first found to be very fragile and short-lived, but was eventually perfected for patent-leather work, and made practical the indestructible quartz lamp of today. An exposure of 2 to 4 hours under the quartz lamp will accomplish as much as a 6-hour exposure to sunlight.

The advantage of this method of treating leather is that no new materials are used. No change is made in manufacture except in the exposure. Wearing tests in shoes, and in leather laid away in piles face to face, has demonstrated that there is no difference between sun-treated and lamp-treated leather.

This method eliminates factory shut-downs during prolonged periods of wet weather, or in extra exposures during the hot, humid days of summer when varnishes dry poorly.

After the leather has been exposed to sunlight or ultra-violet rays, it is stood up in a cool place over night and the next day cut from the frames, trimmed, and piled away face to face for a few days, when it is ready for shipment.

While at present more is understood about the manufacture of patent-leather varnishes and compositions, much more technical skill is required than formerly on account of the varying qualities of linseed oils, and the type of naphthas now supplied, which are not always adapted to the requirements of the patent-leather manufacturer. Close chemical checks should be kept on the oils and solvents used. The oil and naphtha agents should not be blamed, however, because they can only sell what comes to them, but, recognizing what is coming, proper treatment can be given the article in question. This can only be determined by chemical test.

The real problem, however, which confronts a tanner of upper leather, is to make a leather that stands the mechanical treatment of the shoemaker. It almost seems as if the wearing of the shoes was a secondary consideration. Probably the shoeman takes it for granted that all leather will give good satisfaction in shoes.

Leather must stand the heavy pull of the lasting machine

and other devices for making the vamp fit the last snugly. The leather is almost invariably wet before lasting, the tip is not only wet but also stuck to the lining with alcoholic shellac cement; frequently the vamp is soaked in sulphonated oil "to help it," and is often given some secret mixture which the foreman of the lasting room has found effective. In a few places the leather is lasted without treatment.

Attention is called to this treatment previous to lasting, because the patent leather tanner must always have it in mind. All leather is more stretchy when wet or damp than when dry, and all damped or wetted leather contracts on drying, and if stretched too tight when wet and held firmly in place will frequently crack on the grain.

Leather is generally carefully cut into vamps, the cuttings being selected for the proper parts of the shoe.

The vamps are next stitched to the uppers and then dampened, lightly tacked on the last, put into the pulling-over machine, and under heavy pressure made to fit the last snugly, and then tacked. They are left in this condition over night and the next day the soles are stitched on, which operation tightens the vamp still more. A pressure of probably 75 lb. to the square inch is applied and held there. There is no give to this pressure as long as the last stays in the shoe.

Today the shoemaker demands a piece of leather which is more or less firm. Such leather makes a good-looking shoe because it "stands up in the shoe," as they say; in other words, the shoe retains its shape and looks well on the counter. It also wears well and the shoe does not slump over and lose its shape. But the tanning and currying methods which make such a leather also tend to make a weak grain, and a leather, which, when wet, is a bit rubbery, so that on drying there is considerable contraction and a consequent parting of the grain.

The manufacture of patent leather is then a mechanical problem. Glazed kid, box calf, colored calf, and velour leathers all have oil in them, and have never been subjected to any drastic treatment or high temperatures. They are fre-

quently oiled off before being shipped to the shoe factory. In cutting the vamps from such leathers the greatest care is used to get the right selection for the vamps so as to make a good-looking shoe. The exact reverse of this treatment is given patent leather.

Most patent leather is tanned almost to the limit of cracking in order to get the stretch out of the leather. A minimum amount of oil is given it in the fat-liquor, and this is afterwards washed out with a naphtha bath. The leather has 3 or 4 coats of linseed-oil compositions and 3 or 4 days temperature of 110 to 160° F. The character of linseed-oil varnishes is that they are very flexible but only temporarily elastic; that is, they will stretch back and forth about 20 per cent; but if stretched 20 per cent and held, the film parts at once in a long striation. In cutting patent leather, as it all looks good and is all expensive, no selection is made in cutting vamps and "everything goes," so to speak—and does go literally, for bellies, legs, and necks always give trouble.

This characteristic of linseed-varnish film complicates matters. If leather that has received too drastic a treatment in the tannery, or for other reasons has contracted when dried more than it should, is used for vamps, and is soaked and pulled while wet over a last, the varnish, being temporarily elastic, will stretch with the grain. But as the leather again dries and tightens, the varnish, if it has been put on too heavy, is likely to break in long striations. If, on the other hand, the varnish has been applied lightly, the grain may break. A linseed varnish is slightly hygroscopic and is tougher when wet than dry. When patent leather acts as described the result is the discarding of shoes made from it.

In spite of all difficulties, tanning has reached such perfection that most leather stands all the shoe factory roughness and makes good shoes.

The strain on the leather during lasting is greatest over tips and across the ball of the foot. Cracks on the tip can be buffed off, and a heavy varnish, made especially for the purpose, put on. This is called "flowing the tips." When

cracks appear on the ball of the shoe on the inside, the vamp has to be torn off and another put on.

Take at random three patent leathers made by as many different tanners: One of these leathers is made with soft river water, another with artesian well water, the third with lake water. They are all standard leathers, and the success of each one seems to show that the kind of water used has nothing to do with the quality of the leather produced. This means that the tanner has made the best of his local conditions and adapted his methods to meet them.

It is interesting to note that each one of these tanners uses a different beam-house method. One uses straight sulphide, 10 per cent in a paddle-wheel; another 5 per cent lime and 5 per cent sulphide; while a third uses 6 per cent lime and 1 per cent sulphide. They all use different bates.

Two of these people de-grease their leather, and one does not. Two tack their leather out on frames in the tannery, and the other one has the leather stretched in the japanning frames, but does not tack in the tannery. The point is that adaptation of proper methods to the local tannery always produces good leather. The methods must be practical of course. Because one man makes good leather with sulphonated oil it does not mean that he could not do the same with soap and oil. If the reason were traced back why his leather seemed to be better adapted to a sulphonated oil it might lead to the beam-house. And it might be found that it were better to operate the beam-house as it was, rather than change the fat-liquor. The making of a successful leather is the blending of methods and materials which give best results for the local plant.

In the manufacture of patent leather, many tanners take advantage of the fact that hides and skins with poor grain can be successfully put into such leather, which is done by tanning in the usual manner and then snuffing off the grain. In fact, even high-grade side leather is often snuffed in order to make the finish adhere more closely.

## CHAPTER XIII

### DYEING LEATHER

Having carried out the various processes of soaking, depilating, bating, and tanning for glove, fancy, shoe, and other pliable leathers, the next step to be considered is the method employed in coloring the product to meet the demands of the trade. A short description of the various classes of dyes will be given, together with a general outline of their application, and an effort made to point out what conditions are best suited for the different grades.

**Classification of dyestuffs.**—The earliest classification of dyestuffs divided them into two classes, "substantive" and "adjective." Substantive colors are those which are capable of producing a fully developed color upon textile material without the assistance of any other combining substance; adjective dyes are those which require an intermediate combining substance, called a "mordant," to fix and fully develop the color. This grouping is still in use, but during recent years the tendency has been to use the term "direct" color in place of substantive, and mordant color in place of adjective. In general, this classification holds good, but there are certain grades of color that are direct on some fibers, but require a mordant on others.

A classification which divides the dyestuffs according to their origin is of broader application. It recognizes three groups as follows: (1) natural organic dyestuffs; (2) mineral dyestuffs; and (3) artificial organic dyestuffs.

Though the various subdivisions of this classification, particularly of the artificial organic dyestuffs, are numerous, this classification has the advantage that one class does not overlap another.

**Natural organic dyestuffs.**—A subdivision of natural organic dyestuffs is as follows: (1) indigo and related com-

pounds; (2) logwood; (3) dyestuffs producing shades of a red character; and (4) dyestuffs producing shades of a yellow character.

*Indigo.*—Indigo blue or indigotin is found in many plants, but the natural product has been almost completely replaced by the synthetic material. As it has practically no use in the dyeing of leather it is of no particular interest to discuss it in this volume.

*Logwood.*—This is the product of a large tree known as *haemotoxylin campechianum.* The wood is rasped or chipped and extracted with water, and this solution is evaporated either to a syrupy consistence or powder, and is sold as liquid or solid extract. If evaporation be done in an atmosphere free from oxygen, the product is known as unoxidized logwood extract, and contains *haematoxylin* as its active principle. If, however, air is blown through the solution, a change takes place and the product is then known as oxidized logwood extract or hematin, and contains haematein as its active principle.

Logwood is a mordant dyestuff requiring a metallic mordant to fix it on the fiber. This mordant in the leather industry is usually spoken of as a striker. The mordants used with logwood in dyeing leather consist of salts of iron, chromium, copper, nickel, antimony, and titanium. This dyestuff is used in producing black or other dark shades.

*Brazil wood, peach wood, and Japan wood.*—Extracts from these woods are sometimes used in dyeing leather, but require a mordant to develop the color. The metallic mordants used are salts of aluminum, antimony, tin, and titanium.

*Fustic*, or Cuba wood, contains a yellow dyestuff obtained from the wood by leaching. It comes to the tanner as a liquid or solid extract and may be used either with an aluminum, chromium, iron, titanium, or antimony mordant.

*Osage orange.*—The wood of the osage orange contains a bright yellow dyestuff which has largely replaced fustic in the dyeing of leather.

*Cutch.*—This material is used to some extent in producing

brown shades when mordanted with copper. Its application however, is very limited in the dyeing of leather.

**Mineral dyestuffs.**—As a class, these substances are very unimportant so far as their application to leather is concerned. As a color, however, for certain classes of leather finish they are fairly largely employed. In recent years the use of pigments with some form of binder has come into fairly widespread use, and they are not only being employed in finishes, but find application in the actual coloring of the stock.

**Artificial organic dyestuffs.**—The dyestuffs belonging to this group are legion and may be classified according to their derivation, their composition, or in respect to the characteristic, color-forming groups they may contain. As these classifications are of no particular interest to the leather colorer, and as many groups of color have no value when used on animal fiber, we will simply consider such groups as are applied in the dying of leather, which are as follows: (1) basic colors; (2) acid colors; (3) direct colors; (4) alizarine colors; and (5) developed colors.

*Basic colors.*—Chemically the basic dyestuffs belong to that class of compounds known as substituted ammonias or amines. Like ammonia, they are basic in character, hence the name. Basic colors have a direct affinity for vegetable-tanned leather, while with chrome-tanned and other leathers they must be first mordanted with tannic acid before the basic color is applied. Basic colors are characterized by their great brilliancy and high coloring power. They are, however, not very fast to light and do not penetrate the fiber.

*Acid colors.*—These colors are called so on account of their acid character. From a chemical point of view they may be divided into three classes: (1) those which are nitro compounds; (2) those made by treating basic colors with concentrated sulphuric acid, thereby introducing the sulphonic acid ($HSO_3$) group; and (3) those which contain the azo (—N=N—) group.

Acid dyes are applied direct to leather without any mordant. It is customary, however, to give the stock a bottom

of some vegetable coloring material in order to secure fullness of shade. The color is applied in an alkaline solution and is finally fixed by the addition of a small quantity of acetic, formic, or lactic acid. Acid colors are very fast to light and penetrate deeply into the fiber. They are not, however, as brilliant as basic colors.

*Direct colors.*—These colors have a direct affinity for cotton and so get the name. Their method of application to leather is the same as for acid colors, and like them are also fast to light and readily penetrate the fiber.

*Alizarine colors.*—These are derived from anthraquinone, and are usually applied to leather in the presence of sodium dichromate. They are made more soluble by the addition of borax and are fixed upon the fiber by means of an acid. Alizarine colors, like acid and direct colors, are very fast to light and penetrate deeply into the leather.

*Developed colors.*—Such colors as are fixed on the fiber by means of some developing agent are used only to a limited extent, but when once produced give very full shades and are fast to the light.

**Dissolving dyestuffs.**—Natural dyes may be dissolved in boiling water.

Basic dyes are best dissolved in distilled water or rain water. Where only well or river water is available—either of which is more or less hard—the addition of acetic acid is recommended. The basic dyestuff is first made into a thin paste with a little cold water and the requisite amount of acetic acid (generally one-half the amount of acetic acid, 28 per cent, as of dyestuff used is sufficient). This paste is then poured into the necessary amount of hot water (180 to 190° F.) and stirred until completely dissolved. Actual boiling with live steam should be avoided.

Acid dyes are best dissolved by boiling with the requisite amount of water. No acid should be added while dissolving the color or to the stock solution.

Never mix an acid with a basic dye.

**Preparatory treatment before dyeing vegetable-tanned skins.**—In order to obtain satisfactory results it is necessary to prepare the skins properly before dyeing. They are thoroughly soaked and washed in lukewarm water to remove all excess of tannin which might cause difficulty during the dyeing operation. If the tannage is dark it is advisable to give a slight re-tannage after the washing, with light-colored tannins like sumac. This is given in the drum or paddle-wheel and usually requires half an hour. After the tannin has been taken up by the leather it is advisable to fix it with tartar emetic or titanium-potassium oxalate (½ to 1 oz. per dozen skins). These salts are dissolved in water and added to the drum or paddle-wheel after the re-tannage, running the skins 10 to 15 minutes longer. The skins are then rinsed and are ready for dyeing.

**Dyeing vegetable-tanned leather.**—There are four principal methods of dyeing, namely, brush, tray, drum, and paddle dyeing.

*Brush dyeing.*—This is used mostly for large leather, that is, heavy cowhides used in bags, harness, and upholstery; also for light leather in cases where an unstained flesh side is desired. A dyestuff solution of proper strength is applied to the dry leather with a medium hard bristle brush. According to the desired depth of shade one or more coats of the brushing solution are applied. The leather is then hung up to dry.

*Tray dyeing.*—This method is used on light skins only where an unstained or only slightly stained flesh side is desired. The moist skins are either folded singly, (lengthwise), or paired together flesh-to-flesh, and dipped for 5 or 10 minutes in the warm dyestuff solution in the tray until the desired depth of shade is obtained. Then the leather is hung up to dry. Owing to the great amount of labor required for so small an output, this method is not largely employed.

*Drum dyeing.*—This is the method most generally used. Light side leather, kips, horsehide, calf, sheep, and goatskins are all dyed in this manner. The drum is loaded with the

leather and sufficient warm water to allow easy moving of the leather while the drum is running. The temperature of the bath is 100° F. Then the drum is started, and the dyestuff solution is added through the gudgeon while the drum is running. Dyeing requires from 30 to 45 minutes. Other ingredients or chemicals such as acids, metallic salts, etc.,

**Figure 95.—Coloring goatskins.**

which may be required for the proper development of the dyeing, are also added in the same manner.

*Paddle dyeing.*—This is mostly used for the dyeing of very light leathers, such as skivers or light sheepskins which might be torn by the violent pounding in the drum. The paddle-wheel is filled with water at 100° F., the wheel is set in motion, and the damp skins are thrown in. The dyestuff solution is then added in portions by pouring it slowly out of a dipper and alongside the wall of the paddle-wheel. Dyeing requires about a half-hour. Should other chemicals (acid or mineral salts) be needed during the dyeing process they should be added in solution while the paddle-wheel is running. Basic

dyes are dyed without additional chemicals. Acid dyes require the addition of about half the amount of acetic acid as of dyestuff used, or quarter the amount of sulphuric acid.

When the dyeing process is completed, the skins are rinsed in water, set out, oiled off, if necessary, and dried on frames or on hooks.

**Dyeing chrome-tanned leathers.**—These leathers are dyed in the drum. The treatment preparatory to dyeing is as follows:

After shaving, the weight of the leather is determined. This weight serves as the basis for calculating the amount of dyestuffs and chemicals to be used in the dyeing process. The leather is placed in a drum (figure 95), and washed for a half-hour in running cold water: following this it is drained and neutralized. Borax, sodium bicarbonate, wyandotte soda or similar mild alkalies are used for the latter process. According to the acidity of the chrome tannage, 1 to 2 lb. of such alkalies will usually be found sufficient for 100 lb. of leather. Neutralizing is done in the drum at a temperature of 90° F., and requires 30 minutes. An excess of alkali should be avoided. The leather should be almost neutral to litmus paper, or show only a faint acid reaction. After neutralizing, the leather is again washed in lukewarm water and is then ready for bottoming. Bottoming is done with vegetable products, and serves the double purpose of filling the chrome leather and giving a suitable foundation for the dyestuff to be subsequently applied, especially for basic dyes. The products used belong either to the class of tannins, such as osage orange, sumac, gambier, cutch, quermos, etc.; or to the vegetable dyestuffs, such as fustic, quercitrone, hypernic, or logwood. From 1 to 3 lb. of extracts per 100 lb. is generally sufficient. Too much vegetable matter should be avoided, as this is liable to change the character of the chrome tannage. Bottoming is done in the drum at from 90 to 100° F., and requires about 30 minutes. After this period, the vegetable extracts are fixed by the addition of a suitable amount of mineral salts, such as tartar emetic, titanium-potas-

sium oxalate, potassium or sodium dichromate, or similar products; the drum is then run an additional 15 minutes. Two to four ounces of these salts is sufficient for 100 lb. of leather. The leather is then washed in the drum with lukewarm water for 10 to 15 minutes, when it is ready for the dyeing proper.

Both basic and acid dyes are suitable for dyeing this class of leather. The dyeing is done in the drum at a temperature of 125° F., and requires about 30 minutes. The drum is loaded with the leather to be dyed and with sufficient warm water to allow an easy floating of the skins. Then it is started, and the dissolved dyestuff is added in two or three portions through the gudgeon while the drum is in motion. Basic dyes are used without the addition of any acid. Acid dyes sometimes require the addition of a little acetic or sulphuric acid to develop their full strength, 4 oz. of the former or 2 oz. of the latter for 100 lb. of leather is generally sufficient to ensure good exhaustion and full development of a shade. Where acid is used, it is given at the end of the dyeing operation to allow the color to be taken up uniformly before being fixed.

*Blacks on chrome leather.*—These are usually dyed on a logwood bottom. The leather is first bottomed in the drum at 125° F., with from 1 to 1½ lb. of logwood extract or crystals and with a small amount of soda ash (about 2 oz.) for 100 lb. of leather. After running 30 minutes, 4 oz. of copperas or equivalent amounts of other suitable strikers are added, and the running continued for 15 minutes. The leather is then dyed either in the same or in a new bath (the temperature of which is 125° F.) for one-half hour with the necessary amount of National nigrosine or National Erie black; then rinsed, fat-liquored, and finished in the usual way.

*Dyes for chrome-tanned calfskins.*—The following formulas are included by the courtesy of the National Aniline & Chemical Co., they being for dyes used to produce fashionable shades on chrome-tanned calfskins, and are calculated for 100 lb., shaved weight:

### Gold Brown

*Bottom*

3 lb. sumac extract paste
1½ lb. cutch
2¼ oz. titanium-potassium oxalate

*Dye*

12 oz. National resorcine brown R
9¾ oz. National wool orange A conc
1½ oz. National induline NT
1½ oz. National wool scarlet BR
4 oz. sulphuric acid

### Moccasin

*Bottom*

3 lb. sumac extract paste
1½ lb. cutch
2¼ oz. titanium-potassium oxalate

*Dye*

18 oz. National resorcine brown R
18 oz. National azo yellow A 5 W
3¾ oz. National induline NT
6 oz. National fast red S conc.
4 oz. Sulphuric acid

### Cauldron

*Bottom*

3 lb. sumac extract paste
1½ lb. cutch
2¼ oz. titanium-potassium oxalate

*Dye*

12 oz. National resorcine brown R
12 oz. National fast red S. conc.
2¼ oz. National induline NT
3 oz. sulphuric acid

### Chestnut

*Bottom*

3 lb. sumac extract paste
1½ lb. cutch
2¼ oz. titanium-potassium oxalate

*Dye*

12¾ oz. National resorcine brown RN
12 oz. National azo Bordeaux
3¾ oz. National induline NT
4 oz. sulphuric acid

### Morocco

*Bottom*

3 lb. sumac extract paste
1½ lb. hypernic paste
1½ oz. potassium bichromate

*Dye*

12 oz. National resorcine brown RN
16½ oz. National fast red S conc.
3¾ oz. National induline NT
2 oz. sulphuric acid

### Jonquil

*Bottom*

3 lb sumac extract paste
3 oz. tartar emetic

*Dye in fat-liquor*

7½ oz. National metanil yellow 1955
3 oz. National resorcine brown R
2 oz. sulphuric acid

### Aluminum

*Bottom*

3 lb. sumac extract paste
1½ oz. logwood crystals
1½ oz. copperas

*Dye in fat-liquor*

2¼ oz. National resorcine brown R
$\frac{3}{16}$ oz. National metanil yellow 1955
2 oz. titanium-potassium oxalate

### Smoke

*Bottom*

3 lb. sumac extract paste
1½ oz. logwood crystals
1½ oz. copperas

*Dye in fat-liquor*

1½ oz. National nigrosine 27722
1 oz. National metanil yellow 1955

### Black

*Bottom*

1 lb. logwood crystals
2 oz. bicarbonate of soda
2 oz. copperas

*Dye*

1 lb. National nigrosine 128

### Chippendale

*Bottom*

3 lb. sumac extract paste
1½ lb. cutch
1½ oz. titanium-potassium oxalate
8 oz. National resorcine brown R
2 oz. sulphuric acid.

*Top with*

11 oz. National Bismarck brown 53
¼ oz. National Victoria green WB crys.
1 oz. National safranine A

### Gold Brown

*Bottom*

2 lb. sumac extract paste
1 lb. cutch
1½ oz. titanium-potassium oxalate
8. oz. National resorcine brown R
2 oz. sulphuric acid.

*Top with*

9 oz. National chrysoidine Y extra
½ oz. National auramine O
1½ oz. potassium-bichromate

### Morocco

*Bottom*

3 lb. sumac extract paste
1½ lbs. hypernic paste
1½ oz. Potassium bichromate
7½ oz. National fast red S conc.
2½ oz. National buffalo black NBR
2 oz. sulphuric acid

*Top with*

4½ oz. National safranine A
7⅛ oz. National Bismarck brown 53
⅜ oz. National methyl violet 2 B conc. crys.

**Coloring alum-tanned leather.**—This leather is, as a rule, dyed with wood colors which may be shaded with acid dyes; another way is to bottom with wood colors and then top with basic dyes. The wood dyes are the most durable, but the coal-tar dyes are the easiest applied. A mordant is not necessary, as the alum itself acts as a mordant, and the color adheres readily to the alum-tanned fibers. Wood-color extracts in crystal form dissolve readily in boiling water and give clean shades of color on alum-tanned skins. It is necessary to wash the skins thoroughly before coloring them. This is done by running in a drum, giving three changes of warm water (85° F.) and adding a small quantity of ammonium carbonate to the second water, say 2 per cent on the weight of the skins. Washing consumes about an hour. Some skins require more washing than others. A polygonal drum is useful in washing and coloring any kind of leather. When a white flesh and colored grain are desired, the dye is applied to the grain side only by means of a brush or a sponge. Coloring in a drum dyes both the flesh and grain side.

Coloring is carried out best in a drum heated by steam. Anthracene yellows and chromate browns are used in the following manner: The leather is thrown into the drum, and the solution of dyestuff at 120° F. and containing 1 per cent of ammonia, is poured in and the drum run for 15 minutes. A solution of formic acid, well diluted, and in which potassium dichromate is dissolved, is then added to the liquor in the drum. The temperature is raised by steam to 160° F., and the goods drummed at this temperature for 15 minutes. The liquor is allowed to cool to 120° F., when 5 per cent of gambier is added, which is absorbed by the leather in another half-hour's drumming. Finally the skins are rinsed in warm water, set out, dried, and dressed in the customary manner.

The anthracene yellows and anthracene chromate browns can be combined with each other to produce any desired shade. Yellow glove and mitten leather is obtained by coloring with gambier, picric acid, and fustic. Boil 25 lb. of gambier in a barrel three parts full of water. To this solution

add 1 pint of muriate of tin and 3 oz. of tin crystals, and fill the barrel with water. To color 100 skins use from 6 to 10 gallons of this gambier liquor in 4 gallons of water at 90° F., and drum the leather for a half-hour.

Prepare a solution of picric acid and fustic by dissolving 8 oz. of each in 2 gallons of boiling water, to which add 1 gallon of cold water. Pour this solution into the drum with the gambier liquor, and drum the leather 30 minutes. This process of coloring may be applied either before or after fat-liquoring. Staking, drumming with powdered soapstone, and staking again, completes the process of manufacture, and the leather is ready for use.

**Methods of coloring chrome-tanned sheepskins.**—The coloring of chrome-tanned sheepskins is accomplished in various ways. Artificial dyes are in general use. Drum coloring is usually given the preference over the paddle-wheel, tray and brush coloring, as it accomplishes uniform dyeing of a large number of skins in a short time and with little labor. Skins which are to be colored should be prepared with particular care. Only sound skins are suitable and they should be well tanned, free from lime spots and discoloration, and the grain should be as free from natural grease as possible. It is also necessary that the process of tanning used should yield a leather that is soft and full after it has been dried and staked, even though it is given very little fat-liquor or none at all. Complete neutralization of the acid in the skins is also of great importance. Even though acid dyes are applied, it is always best to neutralize the leather before coloring it. Where there is acid in the leather, the fat-liquor is imperfectly absorbed, the dyestuff is liable to be precipitated in the bath, and when finished the leather is likely to spew. If the skins are colored immediately after they have been neutralized and washed, the last washing should be in warm water, thus raising the temperature of the leather in anticipation of the dyeing process. The flesh side should be shaved smooth before the skins are colored. Where fat-liquoring is done previous to dyeing, it is essential that the liquor should penetrate completely into

the leather so that it does not leave the grain greasy or sticky. Before it is colored, the leather should be kept wet and protected as much as possible from light. Dyeing may be accomplished with acid dyestuffs direct, without mordant, or with basic dyes after the skins have been mordanted with tannin.

*Coloring with acid dyestuffs.*—A practical method of coloring with direct or acid dyes is carried out according to the following instructions: The skins, neutralized and shaved, are fat-liquored lightly, and then rinsed in warm water. Twelve gallons of water at 125° F. for each 100 lb. of skins is put into the drum, which is then started. The dyestuff solution is poured through the hollow axle into the drum and the leather is milled from 15 to 25 minutes. Where good penetration is desired, 1 or 2 oz. of ammonia should be added to the liquor in the drum. At the end of this time the dye-bath is acidified by the addition of formic acid. Enough acid should be used to neutralize the ammonia added, and in addition to which, 2 parts by weight of formic acid for every 4 parts of dyestuff, should be used. The acid thus added fixes the color on the leather by 10 minutes' longer drumming.

To increase the fullness of the leather, some sumac or gambier liquor should be added to the dye-bath or run into the drum after the bath has been acidulated. This treatment is particularly advisable if the skins are to be glazed.

The sumac liquor referred to is a decoction of 6 to 8 lb. of sumac leaves or sumac powder in 5 gallons of hot water. Two gallons of such liquor are used for each 100 lb. of leather. After 20 minutes a solution of 3 to 4 oz. of sulphuric acid, or three times as much sodium bisulphate in one gallon of water for each 100 lb. of stock is added gradually while the drum is turning, and the drumming is continued 10 or 15 minutes longer. The colored leather is then rinsed and passed on for further treatment. The temperature of the dye-bath should be from 120 to 140° F. It is good practice to pass the skins through water at 140° F. before throwing them into the drum.

The richest and fullest color results are obtained when

acid colors are topped with basic dyestuffs. This is done by adding a solution of 2 oz. or more of some basic color to the dye-bath as soon as all the acid color has been exhausted from the dye-bath. If this cannot be effected completely, the basic color is applied by drumming the leather in a fresh bath, in which case no further rinsing is necessary.

Acid dyestuffs are dissolved by pouring boiling water over them and boiling to complete solution if necessary. The solution is then passed through a piece of cheese-cloth or a fine sieve, and any particles remaining undissolved are brought into solution by pouring more boiling water over them. Formic acid is used in the dye-baths to get the full shade. The leather is not harmed when an excess of formic acid is used, as it evaporates during the drying of the leather.

*Coloring with basic dyestuffs.*—Basic colors are applied to chrome-tanned sheepskins in the following manner: The neutralized and shaved leather is treated in a drum with a sumac, gambier, or fustic liquor. After this has been done, the dyeing is proceeded with, the process lasting 20 minutes or longer at a temperature of 125° F. It is always advisable to add the solution of dyestuff in several portions through the hollow axle while the drum is turning.

A decoction of 7 or 8 lb. of sumac leaves or sumac powder in 5 gallons of hot water is suitable for mordanting the leather. For very light shades, 6 quarts of such liquor is sufficient for 100 lb. of leather; for dark shades, from 8 to 10 quarts. It should be strained before using. As the sumac bath alone does not fasten the tannin to the skin, a solution of tartar emetic (antimony-potassium tartrate) is generally used to overcome this uncombined condition and fix the color on the leather. After the skins have been treated with the sumac, the solution of tartar emetic is poured into the drum and the process is continued 15 minutes. The leather is then rinsed in warm water, the spent liquor run to waste, and the leather dyed with the basic color in an acid solution. From 8 to 12 oz. of tartar emetic is used for 100 lb. of leather.

*Gambier mordant.*—Two or three pounds of gambier for 100 lb. of leather is another excellent mordant for basic dyes. Boil the gambier in 4 gallons of water, then add cold water to make 12 gallons of liquor. Use at 125° F., and drum the leather with it 30 minutes. Then dissolve 4 oz. of titanium-potassium oxalate in hot water, pour the solution into the drum and run 10 minutes longer. Drain off the liquor and proceed to color the leather with the basic dyestuff.

*Fustic or osage orange mordant.*—Fustic extract is an excellent mordant for shades of tan and yellow. Use from 2 to 3 lb. for 100 lb. of leather. Dissolve in boiling water; then increase to 12 gallons by adding cold water and use at a temperature of 125° F. Drum the leather 20 minutes. Then dissolve and add 4 oz. of titanium salts and let the drum rotate 15 minutes longer. Drain off the liquor and color the leather with basic dyestuff.

Two pounds of gambier and one pound of extract of fustic is also an excellent mordant for basic or acid dyes, and may be used with titanium-potassium oxalate the same as gambier or fustic alone.

*Sumac and titanium-potassium oxalate.*—Four ounces of liquid extract of sumac may be used for each dozen small and medium-sized skins. The sumac is mixed with hot water and the skins drummed with the liquor for 20 minutes. Then pour the solution of titanium-potassium exalate (½ to 1 oz. for a dozen skins) into the drum and run 10 minutes. Wash the skins and dye with basic colors, or dye them with acid colors without first washing.' Dry powdered sumac may be used. The particles of sumac serve the useful purpose of taking up whatever grease there may be on the grain, as well as acting as a mordant by giving up tannic acid.

*Combined dyeing process.*—Bottoming with acid dyestuffs or with diamine and anthracene colors, and then topping with basic dyes, is an excellent method of coloring chrome-tanned sheepskins, especially if they have damaged grain and it is desired to cover up such defects as much as possible. The

coloring is usually done in two baths, namely, the bottoming and the topping bath.

The leather is first drummed with the requisite quantity of fustic extract. The solution of acid dyestuff is then poured into the drum and drumming is continued another half-hour, and complete absorption of the acid dyestuffs is then brought about, if necessary, by the addition of 2 to 3 oz. of acetic acid per 100 lb. of leather, and then a solution of the basic dye added.

Colors of superior fastness may be obtained by adding from 4 to 8 oz. of sodium dichromate to the bath containing alizarine colors, finally adding acetic acid, and working the goods at as high a temperature as possible, say 150 to 160° F. The color solution is then drained out of the drum and the leather is topped with basic colors in a fresh bath.

The skins are fat-liquored either before dyeing or after topping. If the latter, they should be rinsed thoroughly before fat-liquoring. Acid, diamine, alizarine, and basic colors can be recommended for full, even, and rich shades. The quantity of dyestuffs required to color a lot of leather depends, of course, upon the color desired, the size and condition of the skins, and must be decided by the dyer. It is always wise first to try a few dyeing experiments on a small scale.

*Dyeing light shades with acid dyestuffs.*—When light shades such as gray, drab, champagne, pea green, etc., are desired, the skins should be colored in the following manner: They are neutralized, shaved, weighed, treated in a drum with the solution of acid dye, according to the shade, and then set with formic acid. An acid fat-liquor is poured in and the leather drummed 20 minutes. The procedure can also be reversed by first fat-liquoring the skins with an acid fat-liquor and dyeing afterwards. To secure complete penetration, all that is required is to neutralize the skins well and prolong the drumming.

After the leather has been drummed a half-hour it is advisable to add a decoction of sumac or gambier to the bath after the fat-liquor has been exhausted by the leather, and

run the drum another half-hour. Where the color is added to the fat-liquor, which should be alkaline, from 2 to 4 oz. are used for 100 lb. of leather. Acid dyes are particularly suited for coloring light and fancy shades.

*Dyeing with direct colors.*—These colors are of value to the dyer of chrome leather. After the skins have been neutralized and shaved, the solution of direct dye is applied, no mordant being required. After the leather has taken up the color, a solution of sodium dichromate or of copper sulphate should be poured into the drum for the purpose of setting the dye and making it faster to the action of the fat-liquor. A little salt added to the dye-bath will result in good shades. No acid is used and no re-tannage is necessary, and the leather should be perfectly neutral before it is colored. Direct blacks are used successfully with logwood, the leather being dyed first with this and then with the direct black. A good way to use these dyes for colors is to dye with them and then top off with basic dye. Direct dyes are especially useful for coloring leather which is finished dull or on the flesh side. It is best to use acid fat-liquor on leather colored with these dyes.

*Acid colors and sodium bisulphate.*—About 100 lb. of leather can be nicely colored by using acid dyestuffs and sodium bisulphate as follows: The required dyestuff is dissolved in boiling water and made up to 12 gallons of liquor, which is used at 140° F. After the leather has been drummed 20 minutes, 8 oz. of bisulphate is dissolved in hot water and added to the contents of the drum, which is run 10 minutes longer, when all the dyestuff will have been absorbed. The leather is then rinsed with warm water and is fat-liquored. Complete penetration is obtained by adding 2½ oz. of ammonia to the dye-bath and drumming a half hour longer before adding the bisulphate. When this is done, the quantity of bisulphate should be increased slightly to neutralize the ammonia.

*Coloring with phosphine dyestuff.*—Tans and browns of good color and penetration are obtained on chrome sheepskins by the use of phosphines and titanium-potassium oxa-

late. The procedure for 100 lb. of leather is as follows: Drum for 10 minutes with a solution of 3 oz. of oxalate. Then pour 1 lb. of fustic crystals in solution into the drum, and let the leather run 10 minutes. Then add 3 oz. more of the oxalate and drum 10 minutes. Rinse the leather, drain it, and color with phosphine blended with Bismarck brown, both of which are basic dyes, from 2 to 16 oz. of the phosphine and from 1 to 4 oz. of brown according to shade desired.

*Fustic and logwood bottom.*—A mixture of 2 lb. of fustic extract and 2 to 3 oz. of logwood crystals produces excellent results as a bottom for acid colors. After the desired shade has been secured, the skins are drained and treated either with acid fat-liquor or with an emulsion of oil and egg-yolk. Topping acid colors with basic dye is one of the most approved methods of getting tan and golden-brown shades. Formic acid added toward the end of the process increases the depth of color and fastens the color on the leather.

*Sumac and acid color mordant.*—Full, rich shades of tan and brown can be secured by treating as follows: Drum the skins in a solution of 2 lb. of sumac extract and 6 oz. of acid brown aniline for 20 minutes. Then dissolve 5 oz. of titanium-potassium oxalate in a little hot water, pour the solution into the drum and run it for 10 minutes. Wash the skins in two changes of water and color them with basic dyes.

*Practical formulas for popular shades:* 1. Dark tan.—For 100 lb. of leather, drum 30 minutes with $1\frac{1}{4}$ lb. of phosphine at 120° F.; add 5 lb. of fustic extract in solution at 120° F. and drum 30 minutes; finally pour 2 oz. of sodium dichromate at 120° F. into the drum, and run it 20 minutes longer; fat-liquor, set out, and dry the leather.

2. A rich shade of chocolate brown is obtained in the following manner: Boil 2 lb. of gambier and 1 lb. of extract of fustic in 4 gallons of water until dissolved, cool with cold water to make 12 gallons of liquor. Drum 100 lb. of skins for 30 minutes with this liquor; then pour 4 oz. of titanium-potassium oxalate dissolved in hot water into the drum, and run the skins 15 minutes longer. If the mordant has been

taken up by the leather, run off the liquor and pour the dye solution into the drum; if it has not been taken up, it is best to wash the skins before giving them the dye. For 6 dozen skins use 8 oz. of basic yellow and drum the skins 10 minutes; then add 1 lb. of chocolate brown and 8 oz. of Bismarck brown, dissolved together and poured into the drum. Run the drum 20 minutes after the color has been put in; then wash and fat-liquor the skins, and hang them up to dry. Extract of sumac may be used for the mordant if preferred.

3. Golden-rod yellow, Bismarck brown, and champagne colors are efficient in dyeing chrome-tanned skins. A combination of golden-rod yellow and blue and brown produces a fine shade of tan. Mordant the skins with gambier and fustic, apply titanium salt, wash and dye with 20 oz. of auromin, 8 oz. of Bismarck brown, and 8 oz. of methylene blue or malachite green. Drum 20 minutes, and the result is a fine, fast, and uniform shade of tan.

4. An ox-blood color can be secured as follows: For each dozen skins use from 4 to 6 oz. of extract of fustic. Drum the leather 15 minutes with this. Then add to the liquor in the drum 2 oz. of tartar emetic for each dozen skins, and run 15 minutes longer. Wash the skins and prepare a color-bath at 120° F. Use from 2 to 3 oz. of amaranth 3R for each dozen skins and drum 20 minutes, then wash and fat-liquor the skins. The shade can be darkened by using 2 oz. of the amaranth and 1 oz. of chocolate brown for each dozen skins. A liquor made of fustic and peachwood extract is an excellent mordant for wine color. The skins are drummed in this for 20 minutes, when a solution of titanium salts is run in. Then they are drummed 10 minutes, washed, and colored with amaranth, to which a small quantity of malachite green has been added.

5. Alizarine brown and fustic produce a fine shade of color for gloves, linings, etc. For each 100 lb. of leather, dissolve 2 oz. of alizarine brown by boiling in 6 gallons of water. Add 6 gallons of cold water and use at 145° F. Drum 30 minutes. While the skins are being drummed in the alizarine

dye, dissolve 1 quart of fustic extract in 1 gallon of hot water, and at the end of 30 minutes pour the solution into the drum and run 15 minutes longer. Drain off the spent liquor; wash, and fat-liquor.

6. To color chrome sheepskins an attractive shade of green, drum a dozen skins with 4 oz. of sumac extract at 110° F. Then to the bath add 4 oz. of titanium salt dissolved in hot water for 100 lb. of leather. Drum 10 minutes. Drain off the liquor and color, using 3 oz. of either leather green special or dark green M and 1½ oz. of amaranth 1R for each dozen. Drum the skins 20 minutes, wash, and fat-liquor.

7. If a dark olive-green color is required, take the skins from the shavers and for each 100 lb. use 19 gallons of hot water and wash in this for 15 minutes; then drain the drum. Pour in 3 lb. of extract of fustic dissolved in 12 gallons of hot water and run 30 minutes. Make up a solution of 12 oz. of copperas and pour half of this liquor into the drum, and inspect the skins after 15 minutes. If they are dark enough, wash, and fat-liquor; if not dark enough, add more copperas liquor and drum 15 minutes longer; then wash the skins thoroughly and fat-liquor them.

*Coloring after fat-liquoring.*—Uniform results are obtained by coloring chrome sheepskins after they have been fat-liquored. Having been washed and shaved, mordant with gambier or with gambier and fustic, fat-liquor with acid fat-liquor, then color with aniline dyes, and dry them for finishing. This method of coloring is preferred by some dyers. The process can also be varied by fat-liquoring the skins first, then applying the vegetable tanning material and coloring with basic dyestuffs. Titanium-potassium oxalate may be used in the usual manner, and assists in obtaining uniform colors.

The shades most in demand at present may be obtained with the following basic dyestuffs, which can be mixed as desired: paraphosphines, Bismarck browns, leather browns, Russian red, and ox-blood A and B; for darkening the shade, or for saddening basic colors, use neutral blue and solid green crystals.

Acid colors for shades of tan and brown are Indian yellows, acid phosphine, and Havana brown; and for ox-blood, new red B, roccelline mixed with Havana brown or acid phosphine J I. For saddening the shade or as a saddening agent for acid colors, use naphthol black B and fast acid green B.

*Flesh-finished chrome sheepskins.*—For some purposes, sheepskins finished on the flesh side with a soft, velvety finish are required. Skins that have defective grain are used for this class of leather, since the value of the leather does not depend upon the quality of the grain. The leather is made by the usual methods of chrome tanning, but instead of being finished on the grain, the skins are dressed smooth and velvety on the flesh side.

After the skins have been neutralized and washed they are put into a drum with 4 gallons of water and 5 lb. of pipeclay for 100 lb. of leather, and are milled for 20 minutes. They are then run on a wet wheel which gives a good face to the leather. After this has been done they are run in warm water and then colored. Coloring is done in the same manner as on grain-finished skins. Fustic, gambier, and sumac are used as mordants for basic dyes. Wood dyes are also used in conjunction with titanium salt. A satisfactory method of coloring is to apply acid dyestuffs in a drum. Good penetration is essential on this leather, and it is helpful to add 1 to 2 oz. of ammonia to the dye liquor. At the end of 20 or 25 minutes, 2 parts by weight of formic acid for every 4 parts by weight of dyestuff are added to the drum to acidify the bath. A little more than this quantity of acid may be necessary to neutralize the ammonia previously added. The leather is drummed 10 minutes longer. Some sumac or gambier liquor added after the bath has been acidulated imparts a feeling of fullness to the skins. As a fat-liquor, an emulsion of egg-yolk, olive oil, castile soap, and flour is especially suitable; but a less expensive liquor can be used. The skins, after coloring, are washed and fat-liquored.

Drying and staking are carried out in the usual manner.

Staking on a machine should be followed by knee-staking to eliminate all stretch. The skins should then be given a light buffing on a very fine emery wheel, and are then ready to be trimmed and sorted. If the work has been properly done, the skins finish soft, are evenly colored, and have a smooth, velvet-like face.

If white skins are required, the tanning process is followed by treatment with flour; fat-liquoring and finishing being done as already described.

*Coloring chrome-tanned sheepskins after fat-liquoring and drying out.*—Chrome sheepskins take color well before they have been fat-liquored and dried, but it is generally considered impracticable to dye such skins after they have been dried out. However, this has been proved to be incorrect, as good results may be secured in the following manner:

After the skins have been fat-liquored and dried out they are soaked and are ready for dyeing. This is best effected in a drum fitted with steam pipes; neither the paddle nor the tray are suitable without some arrangement for keeping the dye hot. Dyeing is best carried out at a temperature of 140° F.

The method is as follows, for a dozen skins: 8 to 10 oz. of the dye is carefully weighed out into a wooden tub and dissolved by pouring on it about 200 times its weight of boiling water, stirring briskly. Then 8 to 10 oz. of sodium bisulphate is dissolved in hot water in a separate vessel. Half of the concentrated dye solution is now added, with the bisulphate solution, to enough water at 140° F. in the drum to cover the skin. The leather is placed on the shelf, and the drum is started. After running the goods in this dye-bath for 15 minutes, the remainder of the dye solution is added and milling is continued for 30 minutes longer, or until the goods have attained the depth of shade required. After dyeing, the skins are washed in warm water, set out, lightly rubbed over the grain with glycerine, and dried out while strained on boards.

*Blacking with hematin and direct chrome black.*—A fine rich black is obtained on chrome sheepskins by the following

method: Dissolve 1 lb. of hematin crystals for 100 lb. of leather in 4 gallons of boiling water, add 6 or 8 gallons of cold water and a little ammonia to make it slightly alkaline, and use at a temperature of 125° F. After the leather has been run in this dye for 15 minutes, add 1½ lb. of chrome leather black dissolved in 5 gallons of boiling water to the liquor in the drum, and run the leather 15 minutes longer. Drain the drum and pour in the fat-liquor; then run the drum for a half-hour; wash the skins in warm water, set out, oil the grain lightly with neat's foot or mineral seal oil, and hang up to dry.

Sheepskins which are to be given a glazed finish, are benefited by a light re-tannage with gambier before they are dyed. This assists in getting a fine color and finish, and makes the leather less stretchy. The skins may be paddled or drummed in the gambier liquor.

*Blacking with logwood and titanium-potassium oxalate.*—In this process of dyeing, logwood extract or crystals, titanium salt, and direct chrome black are used, the quantities given below being for 100 lb. of shaved leather. Drum the leather in a solution of 3 oz. of titanium-potassium oxalate for 10 minutes, then pour in a solution of 2 lb. of logwood, ½ lb. of chrome leather black, and 4 oz. of ammonia in 12 gallons of water. Drum the skins in this liquor for 20 minutes; then pour in a solution of 3 oz. of titanium-potassium oxalate and allow the drum to run 10 minutes longer. Then either drain the drum and run in the fat-liquor, or wash the skins and then fat-liquor.

*Blacking with direct chrome black.*—Put the leather, neutralized and shaved, into the drum with 10 gallons of water at 125° F. for each 100 lb. Run for a few minutes, then pour the solution of dyestuffs through the hollow axle of the drum. Dyeing will be completed after about a half-hour's drumming. For blue-black with a blue flesh side, use from 1 to 1½ lb. of chrome leather black. It is advisable to add a small quantity of logwood liquor to the dye-bath after a short drumming to fill the leather somewhat.

Fat-liquoring may be done either before, during, or after dyeing. If the fat-liquor is added to the dye-bath it is advisable to drum the leather in the dye liquor for 15 minutes before adding the former. Another method of blacking with direct chrome leather dyes is as follows: Use 4 or 5 oz. of nigrosine G and 4 oz. of chrome leather black C for 100 lb. of leather. This produces the desired fine grain black and the blue-black flesh. Chrome leather black C used alone also produces blue-black flesh and black grain. The leather, thoroughly neutralized and treated with alkaline fat-liquor, is dyed for 30 minutes in a drum with 2 lb. of dye for 100 lb. of leather, at a temperature of 120 to 140° F.

By dyeing first with 8 to 10 oz. of chrome leather black C for 20 minutes, then adding 1 oz. of acetic acid and 10 minutes later a solution of 8 oz. of leather black T B, drumming the leather 10 minutes more, and then fat-liquoring, a fine color is secured on both flesh and grain sides. A little logwood extract liquor added to the dye is beneficial, increasing the fullness of the leather.

**Methods of dyeing vegetable-tanned skins:** *Blacking vegetable-tanned skins.*—There are many methods of dyeing black on gambier, quebracho, sumac, or combination-tanned leather. One of the newer and better processes is by the use of logwood and titanium-potassium oxalate. Drum the skins in a solution of 4 oz. of the titanium salt for 100 lb. of dry leather; next pour slightly alkaline logwood or hematin liquor —made by dissolving 4 lb. of liquid extract in 5 gallons of water—into the drum, and after the leather has been treated with this for 15 minutes, pour in 4 oz. more of the titanium salt; drum 10 minutes longer, then wash and fat-liquor. No copperas, iron liquor, or other striker is required. The titanium-potassium oxalate after logwood produces a soft, deep, and permanent black.

When soft black leather is wanted, the following procedure may be adopted: Take the skins out of the tan liquor, wash, and press them. Then treat with acid fat-liquor, or with an emulsion of soap and oil, and dry out in the usual manner.

When dry, soften the skins with warm water and dye as already described; then wash and dry for finishing. A few ounces of fustic paste or crystals boiled with the logwood makes the black deeper and richer. For some purposes the skins work out sufficiently soft without being fat-liquored, but if soft leather is desired, they should be fat-liquored immediately after tanning, or after they have been colored.

There are several direct blacks obtainable which dye the leather a deep black without the use of logwood. When the flesh side has to be colored, the skins are drummed with the solution of dyestuffs; and when it is to be left uncolored the black is applied by hand to the grain side only. If the flesh side is to remain undyed, the staining process is to use a solution of direct black heated to 125° F. and applied directly to the grain by means of a brush. Usually two coats are sufficient.

If the flesh side is to be colored blue, purple, or blue-black, the skins are drummed with the solution of black and then stained on the grain with the same dye, washed, and dried. For leather that is to be given a glazed or other bright finish, a black with a greenish cast is preferred.

*Dyeing with acid and basic dyestuffs.*—Fancy-colored skins must have clear and uniform colors to give satisfaction, but it is not an easy matter to get such colors unless the grain is sound and free from excess of tannin. Tanning should be done in clean liquors, and all excess of tannin should be eliminated before coloring is started. The dye, especially a basic dye, quickly strikes defective spots in the grain, and on account of the precipitation of the dye on such spots, and the darker coloring resulting therefrom, the finished leather shows an unevenly colored grain which detracts from its value. Tartar emetic is useful in removing surplus tannin from the grain, fixing the dye on the leather, and getting uniform shades. Basic dyestuffs are also deposited on the skins rapidly, which often causes uneven coloring. Acid dyes color more slowly than basic dyes, and more time is therefore required for the production of well developed shades; but the colors are gener-

ally more uniform and more permanent, and the defective spots do not show as plainly as when basic dyes are used.

The skins are usually dried after they are tanned, and are softened and washed and cleared before they are colored. They are shaved to secure uniform thickness. When the washing is properly done, the colors are clear, full, and deep. The dry skins are moistened in a tub, and left in piles for some hours to become soft and wet; or they may be moistened in a drum. The water used for this work should be soft and warm, as such water has greater softening and cleansing power than cold water. A safe temperature is from 85 to 95° F. The skins are washed until soft and clean.

Sorting for black and colors is best done before the skins are washed. The light shades require leather free from defects, while the dark shades allow of a certain amount of covering from the dye-bath.

*Coloring with artificial dyestuffs.*—Sumac freshens up the skins so that they readily take the dye liquor, therefore, 4 oz. of sumac extract for each dozen skins is placed in the mill and the skins are drummed in this solution for 20 minutes. To clear the grain and set the dye, a solution containing 2 oz. of tartar emetic for each dozen skins is poured into the drum, and the skins are run 15 minutes longer. After this it is best to rinse the skins in warm water, drain the drum, and return the skins to color them. From 2 to 4 oz. of dyestuff is required by each dozen skins. The temperature of the dye-bath should be about 100° F. Fustic may be used instead of sumac. Either basic or acid dyes may be used on the skins prepared in this manner. Dyeing is usually commenced by entering the skins in a weak dye-bath, which is gradually brought to full strength. A fairly even temperature of 120° F. should be maintained, and on this account it is advisable to heat the skins in hot water before passing them into the dye-bath. Some dyers color with acid colors and then top off with basic colors. When this is done, it is best to apply the basic dye in a fresh bath so that there may be no precipitation of the dyestuff in the liquor.

Another method of preparing the skins for dyeing is as follows: The dry leather is moistened and softened, then run in a solution of 8 oz. of titanium-potassium oxalate for every 100 lb. of dry skins. Drumming with this solution for 10 minutes gives a yellow base on which any shade of tan, brown, ox-blood, etc., can be easily obtained.

If acid dyes are to be used, the skins may be colored at the end of 10 minutes without being washed; if basic dyes are to be applied after the drumming in the titanium solution, the liquor should be run off, and the skins washed and then put in the dye liquor.

Where extract of fustic is used as a mordant, $1\frac{1}{2}$ pints dissolved in a pail of boiling water should be used for 100 lb. of leather. The skins, together with enough water to float them, are put into the drum which is set in motion. The fustic solution is next slowly poured in, and drumming is continued 20 minutes. A solution of 4 oz. of titanium-potassium oxalate is then added to the liquor, and the leather is run 15 minutes longer. The skins can then be either fat-liquored and dyed, or dyed first, and then fat-liquored.

After the leather has been running in the solution of acid dyestuff for 20 minutes, 4 oz. of formic acid for each 100 lb. of leather is poured into the dye-bath to exhaust it on the leather; the drum is run 10 minutes longer, and the skins are then rinsed and fat-liquored.

*Ox-blood shade.*—1. For 100 lb. of dry leather previously treated with sumac, use 8 oz. of titanium-potassium oxalate. Soften the skins with warm water and drum them in the solution of titanium salt at 95° F. for 10 minutes. Drain the drum and rinse the skins; then dye them. One dozen skins of average size require about 6 oz. of amaranth 3R and $\frac{1}{8}$ oz. of malachite green. Dissolve these dyes in 1 gallon of hot water, add 7 gallons of cold water, apply to the skins at 100° F., and drum 15 minutes; then wash and fat-liquor.

2. Directions for coloring 10 dozen skins: Moisten with warm water, and run in the drum with water at 90° F. Dissolve 3 lb. of tartar emetic in hot water. Pour the solution

into the drum, and run the drum 15 minutes; then drain off the liquor. To color, use 4 lb. of amaranth 3R, adding to the skins in four portions at intervals of 10 minutes. Then add $1\frac{1}{2}$ lb. of amaranth 1R with 8 oz. of chocolate brown, and run the drum a half-hour. Drain off the liquor, run in the fat-liquor, add 10 oz. of potassium bichromate, and let the drum revolve 10 minutes longer; then wash the skins and dry for finishing.

3. A good shade of ox-blood can be obtained on vegetable-tanned skins in the following manner: Boil 10 lb. of hypernic chips and strain the liquor. Put the skins in drum with water at 90° F. Add the hypernic solution while the drum is running, and mill the skins for a half-hour. Dissolve 7 oz. of amaranth 3R in 1 gallon of water. Strain the solution through cheese-cloth and cool to 110° F. by adding cold water. Apply this to the leather in three portions at intervals of 5 minutes, running the drum 15 minutes after the last of the dye is added. Drain out the spent dye liquor, rinse the skins in clean, warm water, and then drum with a solution of 3 oz. of potassium bichromate for 15 minutes and finally fat-liquor.

*Brown shades.*—1. Mordant the skins with sumac and titanium-potassium oxalate, then dye with 1 oz. of leather brown F for each large skin, and less for smaller ones. Drum the leather for a half-hour, wash, and fat-liquor.

2. Another excellent shade of brown can be obtained by drumming the skins in a solution of titanium-potassium oxalate for 10 minutes; drain the drum and add the color solution made of 4 oz. of phosphine, $\frac{1}{4}$ oz. malachite green, and $\frac{1}{2}$ oz. methyl-violet 2 B; and run the leather in the dye for 15 minutes, finally washing and finishing it.

Tans and browns, all shades, are produced by the following method: For each 100 lb. of dry leather, sumacked, washed, and cleaned, use 1 to 3 lb. of phosphine and 1 to 8 oz. of Bismarck brown, according to the depth of shade required. Drum the leather in the color-bath for a half-hour, or until

it is exhausted. Add 4 to 10 oz. of titanium-potassium oxalate dissolved in hot water, and drum 10 minutes more and rinse well. If not previously fat-liquored, apply such liquor and dry the skins for finishing.

Tartar emetic may also be used on the skins after they have been run in the sumac liquor, the goods then being washed and colored. Leather which is dark, greasy, and dirty can be much improved by using borax and sulphuric acid. Put the skins into the drum with warm water containing considerable borax, and wash them 20 minutes. Drain off the borax bath and put warm water acidified with sulphuric acid into the drum, and wash the skins 10 minutes, rinse in clean water, make a sumac bath strong and hot, add a little salt to it, and drum the leather in this for 30 minutes; rinse in warm water, and strike out the leather for coloring. Run it in warm titanium solution, then in the dye, rinse, and finish.

*Dyeing with fancy effects.*—By a special preparation or by manipulation of the leather, or by suitable application of the dyestuff, a great variety of effects may be produced, of which those described in the following notes meet the present demands of fashion.

*Marbled effects.*—These are obtained by folding the moist leather prepared for the dyeing into a great number of irregular pleats, and pressing the pleats so formed as firmly and as closely together as possible, whereupon the leather is dyed either by spraying on the dye, or by placing it on a metal plate and dipping it quickly into the liquor. This must be done rapidly. The leather is then rinsed in pure water kept ready. The greatest variety of effects may be obtained by repeating the operation several times with different color solutions, and the effect may still further be varied by treating in like manner leather previously dyed a uniform shade. The method of dressing which follows is the same as usual.

*Spray dyeing.*—This is carried out with various dyestuff solutions by means of a blowpipe provided with a fine nozzle, the leather being spread out flat on a table or hung on

hooks. There is of course plenty of scope for a great variety of effects, according to the dyestuff solutions applied, the leather, if desired, being previously dyed to some uniform shade, or stencil plates are used, which again varies the effects obtained by this process. To ensure good fastness to rubbing and water, solutions of color soluble in alcohol, with the addition of some shellac, are frequently used for spraying. "Changeant" dyeings are produced by spraying the color solution sideways onto the previously pressed leather, the side opposite to the pressed parts thus remains either undyed, or is sprayed over with a different color solution.

*Antique leather.*—This method is also frequently applied for producing so-called antique leather. The rough, irregular, and wrinkled effects in favor for leather of this description are produced by pleating the skins and crushing them up tightly in sacks, or nets, treating them in strong tanning solutions, and only opening the bundles to complete the tanning, when there is no longer any fear of the wrinkles disappearing. The antique grain may also be imparted to the leather by embossing. In dressing leather of this kind, the wrinkles should be well preserved and superfluous setting-out avoided.

Various methods are applied for producing antique effects, for instance: The raised portions of the grain of the previously dyed and dried leather are buffed by means of fine emery paper or pumice. The raised portions of the surface of the previously dyed and dried leather are given a coating with a "fatty resist" consisting of wax and vaseline, whereupon the deeper portions are dyed by means of a soft sponge or a brush, or by spray dyeing. All parts protected by the "wax resist" remain undyed. Any excess of dyestuff which may be present is then removed with a moist sponge and the leather is dried. The dyestuff intended to stain the deeper portions of the grain has to be applied in a rather highly concentrated form, owing to its rapid absorption, and it is advisable for such purpose to use acid dyestuffs or basic colors which have no tendency to bronze. The wax resist may, if necessary, be replaced by collodion varnish.

If collodion varnish colored with cerasine and mineral colors are used for dyeing the deeper portions of the grain of the previously dyed and dried leather, the leather is first given a coating of thin Irish-moss decoction. When dry, suitably stained collodion varnish is applied, which, after being allowed to dry for a short time, is removed from the raised portions of the grain by means of a linen pad dipped into amyl-acetate and pressed out well, the bottom shade then reappearing. Antique effects may likewise be obtained in the reverse manner by dyeing the raised portions of the grain with colored gelatine, shellac dissolved in spirits, or collodion varnish, the deeper parts of the grain thus retaining the original shade. By clever manipulation, exceedingly handsome and entirely original effects may be produced. When using collodion varnish it is better to add some castor oil, in which the dyestuff may be dissolved, to enhance the pliability of the leather.

Shellac dissolved in spirits may be colored with basic colors or with dyestuffs soluble in spirits, and collodion varnish with cerasine colors and the addition of mineral colors, to any desired shade.

To remove from the leather the smell peculiar to collodion varnish with which it has been treated it is hung up for some time in a well-ventilated room at a temperature of 110° F. The subsequent dressing is the same as for colored leather.

*Bronze dyeings (dyeings with metallic luster)*.—The leather is first dyed in the tray with a solution containing 1 to $1\frac{1}{2}$ oz. of some suitable basic color to $1\frac{1}{2}$ gallons of water (dissolved with the addition of alcohol), then rinsed, and topped with a solution containing up to 2 oz. of a suitable acid color per $1\frac{1}{2}$ gallons. It is better to treat such leather before dyeing with a solution of tartar emetic. After this dyeing in the tray, the leather is struck out on the flesh side, the grain being oiled lightly with linseed oil, and dried. The subsequent glazing may be facilitated by lightly rubbing the grain side, immediately before the glazing, with a cloth containing a little linseed oil.

The following is another method of producing bronze dyeing of particularly good resistance to water: The leather is first dyed as desired with a strong solution of basic color. After drying, it is glazed by machine, and then coated with a stained collodion varnish diluted with about half its weight of amyl-acetate, and then dried. This treatment is repeated if necessary, and yields an intense bronze luster, which may be still further enhanced by severe glazing. For so-called velvet or antelope shades a very deep penetration is required as a rule. This effect is produced on buffed, bark-tanned and sumac-tanned cowhides and calfskins, or are imitated by dyeing the flesh side of bark-tanned sheepskins. This is ensured to best advantage by working according to the following method: The leather is first prepared like other colored leather, buffed in a dry state, and soaked. It is then dyed warm in the drum with acid colors, some ammonia being added at the beginning of the operation. The material is dyed for about an hour, the requisite quantity of formic acid, up to ½ per cent, being added towards the end of the dyeing operation. The leather is then rinsed thoroughly, set out, oiled, and dried. Some shades, especially black, may be produced to good advantage by topping the acid colors with basic colors. Black, for instance, is produced by dyeing with 2 per cent of nigrosine, shaded if necessary with other dyestuffs, the acid being added after about an hour's dyeing, and the leather topped with 1 per cent of leather black T B or velvet black B, and some alum or acetic acid. The leather is then dyed for about another 20 minutes, rinsed, set out, oiled, and dried in the usual manner.

When dyeing these leathers by the staining process, the solutions of acid colors are brushed on without the addition of acid; the leather is then dried, and the second coloring applied, this time with the addition of formic acid in order to fix the acid color. A dense shade of black is produced with about 1 lb. of nigrosine, shaded if necessary with orange, etc., and the addition of 8 oz. of formic acid for 10 gallons of

dye liquor, the leather being then dried. This treatment is followed by the application of another solution of 1 lb. of leather black T B in 10 gallons of staining liquor. A preparatory treatment with titanium-potassium oxalate, and an after-treatment if necessary with a tanning solution, enhances the fastness to rubbing.

**Coloring and finishing India-tanned skins.**—India-tanned sheepskins and goatskins in various colors and finishes are used for the manufacture of shopping-bags, traveling-bags, belts, collar-boxes, bookbindings, carriage trimmings, linings, etc., and in making leather novelties and specialties. They can be finished with any kind of grain, in any color, glazed or dull, smooth-grained or embossed; they can likewise be made soft or firm as may be desired. Large, heavy skins are used for suitcases and bags; the smaller ones for purposes where light, soft leather is suitable. Bookbinders use India skins in a variety of colors, the staples being pebbled grain, dark green, dark blue, wines, and blacks. As bookbinders' leather must be fairly thin to cover the backs and corners of books, the skins are split to the thickness required.

*Washing.*—The water used should be at a temperature of 90° F., and its efficacy is enhanced by adding some borax or washing soda, from 2 to 3 lb. for 100 gallons of water. The skins are washed in this solution for 15 or 20 minutes, then in clear water and made ready for further treatment. It is necessary to re-tan the skins with some tannage that makes soft and light-colored leather; and if for light shades, it is necessary to bleach the skins with acetic acid after the borax bath. The borax cleanses the skins perfectly, but darkens the color; the acid-bath serves to brighten up the color. The skins are drummed in the acid solution (from 2 to 3 oz. of acid per gallon of water may be used), then washed thoroughly to remove every trace of it, when they are ready for the sumac treatment.

*Re-tanning with sumac.*—The sumac liquor should be strong and at a temperature of 105° F., and the leather should

be treated in a drum or in a paddle. One to two pounds of sumac should be used for each dozen skins. The leather is run in this sumac liquor for 30 minutes to an hour, after which it is washed in warm water, struck out with a slicker, and hung up to dry. When dry, it can be dyed any shade of color.

Instead of sumac, quermos extract may be used, as it produces a light color and is stainless. After the washing from the re-tan, the skins have a good color and for some purposes they can be finished without dyeing. The borax removes some of the tanning material and much of the natural grease. The acid bath brightens the leather and the sumac replaces the tan washed out, thus making the skins softer and the grain better prepared for subsequent dyeing. Some tanners use sodium hyposulphite in the wash-bath in place of borax, 10 lb. being dissolved in a barrel of hot water; the solution is used at 110° F., and washing for a few minutes, only. The use of normal sodium sulphite, or the tri-calcium phosphate, with acetic acid, to clear the skins before going into the sumac, is somewhat milder and gives satisfactory results.

*Coloring the skins.*—To prepare the dry leather for coloring it is moistened with warm water. For single pairs of skins the tray is used, while for larger quantities the drum is necessary.

The dyeing process is usually begun by entering the skins in a weak dye-bath, which is gradually brought to its full strength. For single pairs, 8 or 10 minutes is sufficient; for larger numbers, from 15 to 30 minutes should be allowed. A fairly even temperature of about 115 to 120° F. should be maintained, and on this account the skins are sometimes heated before they are placed in the warm liquor. The weights of dyestuffs are calculated on the number of skins, the average size being generally taken. Light shades require 1 to $1\frac{1}{2}$ oz., medium shades $1\frac{3}{4}$ to $2\frac{1}{4}$ oz., and full shades up to 5 oz. per dozen.

1 One method of coloring the skins is as follows: They

are run in a drum with warm water until they are soft and open. For each dozen skins from 2 to 5 oz. of tartar emetic in solution is added, and the drum is run 15 minutes. This clears the grain and sets the tannic acid. The water is then drained out of the drum and the skins are colored with basic dyestuffs.

2. Another process is to drum the skins for 10 or 15 minutes in a warm solution of 6 to 8 oz. of titanium-potassium oxalate for each 100 lb. of dry leather, then rinse and apply the dye. This process is recommended, since it mordants with titanium tannate, itself a yellowish shade, on which bottom all shades of tan, brown, green, blue, and maroon can be easily obtained. After running off the liquor, a slight rinsing with warm water is advisable but not always necessary. If acid dye is to be applied, the rinsing may be omitted; if basic dye is to be used, it is necessary to wash the skins only when the mordant bath has not been fully exhausted. After the desired shade is obtained, the leather is washed and finished.

The dyed skins which are to be glazed subsequently should, on leaving the liquor, correspond approximately in shade with the dry pattern; if they are to remain dull or are to be glazed but lightly, a wet portion of the pattern should be used for matching. After dyeing, the leather is rinsed, set out, and tacked on boards.

*Dyeing the skins black.*—1. India-tanned skins can be blacked through flesh and grain by using logwood and titanium-potassium oxalate. A fairly strong logwood liquor, slightly alkaline, should be used, and 10 oz. of titanium salt for 100 lb. of dry leather. Dissolve the latter and drum the leather in the solution for 10 minutes, then drum with the logwood liquor for 15 minutes. No copperas or iron liquor is used, as the logwood and titanium-potassium oxalate dye a deep, permanent black. It is advantageous to use logwood crystals and add a little fustic paste to the liquor to intensify the black.

2. To dye flesh and grain of the re-tanned leather, the skins

should be first drummed in a solution of methyl-violet and then in a basic black solution. For 250 lb. of dry leather, 8 oz. of methyl-violet and 5 or 6 oz. of basic black are required. Drum in the violet solution for 20 minutes, then for 15 minutes in the basic black liquor to which 4 oz. of titanium salt in solution has been added, wash and finish.

3. Where the flesh side of the skins is to be left uncolored,

Figure 96.—Top pan blacking machine used for seasoning and coloring.

or to be dyed black or dark blue, the use of the direct leather black can be recommended.

If the flesh side of the skins is to be left undyed, the black is applied to the grain side by the staining or brushing process. The dye solution consists of 1 lb. of dyestuff and 8 oz. of acetic acid in 10 gallons of water. The dye liquor should, during its application, be kept at 130° F., and be thoroughly brushed into the grain. Usually two applications are sufficient for dry leather.

4. If the flesh side of the leather is also to be dyed, direct leather black is applied in a paddle or drum, preferably the latter. Usually 1½ lb. of the dyestuff per 100 lb. of leather

is required, to which 3 to 5 oz. of acetic acid is added with the necessary volume of water.

5. Where the flesh side of the skins is to be dyed dark blue and the grain black, the leather is first dyed with the direct black in a drum for half an hour at 115° F. It is then strongly set out, and after having been dried, is dyed on the grain by the staining or brushing method with the same material.

6. The skins can also be flesh-colored by the use of blue nigrosine. For each dozen skins, 2 to 3 oz. of nigrosine is dissolved in hot water and applied at 110° F. The skins are drummed in the solution for 20 minutes, and then blacked on the grain by hand or on a machine with logwood and iron liquor.

7. The leather can also be dyed by being first drummed in logwood liquor and then the color developed in the drum by the addition of iron liquor, or by passing the leather through the grain-blacking machine shown in figure 96.

Drumming the leather in a warm solution of sulphonated oil or adding the oil to the logwood liquor increases its softness and improves its texture.

*Ooze leather.*—This is prepared by snuffing the grain until it has a soft, velvety appearance. Dyes for ooze leather should be selected for their penetrating power. Excellent results in coloring sheepskins may be obtained by dyeing first with acid colors, as, for example, dyeing coffee shades, first with Indian yellow G; tan shades, first with orange extra; and red-brown shades, first with fast brown B N, and then topping with the proper mixture of diamine phosphine J. Bismarck brown E E, methylene blue B B, or new blue R.

The acid dyes produce an excellent level bottom for the basic colors. Light pearl, gray, champagne, blue, and heliotrope are most successfully obtained with easily leveling dyes, such as cyanole fast green, cyanole F F, lanafuchsine S G and S B, orange extra, and acid yellow A T. These dyes give also good fastness to light.

**Coloring chamois leather.**—Dyeing this class of leather is not as simple a process as dyeing vegetable-tanned skins. The oil-tanned fibers do not take up the dye readily unless the skins have been previously mordanted. The most common mordants used for this class of goods are chrome-alum and potassium dichromate, especially when alizarine dyes are used. The leather must be wet back with warm water, and the excess of oil removed. For this purpose the goods are drummed in a solution of washing soda at 95° F.; an excess of soda is not very harmful unless the temperature is too high, a suitable strength being about 2 per cent. When the grease has been removed in this way, the goods may be fat-liquored lightly and dried out. If the skins are for light shades, they can be bleached with sodium peroxide and sulphuric acid, or with potassium permanganate and sulphurous acid. When the goods have been dried, they are fluffed on one side and again wet-down. Mordanting with chrome-alum follows, which is best done in the drum. The chrome-alum is dissolved to make a 1½ to 2 per cent solution, and this liquor placed in the drum with the goods, about 25 gallons being sufficient for 6 dozen skins. Drumming is continued until the chrome-alum has entirely penetrated the thickest parts, which usually takes from 30 to 40 minutes. When the mordant has penetrated the goods they are ready to be dyed. For this purpose it is customary for the dye to be added to the mordant bath without running it away, but it is better to remove the goods from the mordant bath and treat in a fresh dye-bath.

As already stated, alizarine colors are used for this class of goods. The dyestuff should be dissolved in boiling water, and the color developed by the addition of sodium bisulphate at a temperature of 115° F. Half of the dye to be used is added to the drum and the goods are milled for 20 minutes. The quantity of bisulphate then added is about twice the weight of the dye-stuff used, and the remainder of the dye is introduced. Drumming is continued for 20 minutes, when the goods should be thoroughly dyed, the color having penetrated

completely through the fibers. After fat-liquoring and drying, the goods are ready for finishing.

**Dyeing chrome-tanned calfskins black:** 1. *Dyeing with logwood and direct leather black.*—The use of a direct chrome leather black, combined with logwood or some product of logwood, is the most approved method of dyeing chrome calfskins black. A typical formula is: hematin crystals, 1 lb.; ammonia, 1 oz.; and chrome leather black C, 1½ lb. for each 100 lb., shaved weight.

The skins are thrown into the drum together with 8 or 10 gallons of warm water. The logwood or hematin liquor, made by dissolving the dye in 2 or 3 gallons of boiling water, and made alkaline by the addition of the ammonia, is then poured into the mill and the leather is drummed for 15 minutes. The chrome leather black dissolved in 4 gallons of boiling water is next added to the liquor in the drum through the trunnion, and the leather is drummed 15 minutes longer.

2. *Dyeing with logwood, leather black and titanium salt.*—A rich black is obtained by carrying out the following instructions, the quantities of dyestuffs mentioned being sufficient for 100 lb. of leather: Drum the leather in a solution of 3 oz. of titanium-potassium oxalate for 10 minutes. Dissolve, by boiling in 8 gallons of water, 1½ lb. of logwood crystals, ½ lb. of chrome leather black, and 4 oz. of sal-soda, and drum the leather in this liquor for 15 minutes. Then pour in another solution of 3 oz. of the titanium salt and continue drumming 10 minutes longer. The leather is then fat-liquored.

3. *Dyeing with acid-blacks.*—This method of blacking the leather is preferable if the skins have not been entirely neutralized or if special value is placed on good penetration. From 1½ to 2 lb. of nerazine G or of neutral black B are required for 100 lb. of leather. The leather is run for a few minutes with 10 gallons of water at 130° F. The dissolved dyestuff is then poured into the drum, and the drumming is continued for 20 minutes. About 1 lb. of formic acid is then

added and the drum is run for 10 minutes longer. For filling the leather, a fairly large quantity of logwood extract or gambier may be added to the dye-bath. When this method of dyeing is used, it is best to fat-liquor before dyeing, since the black is likely to bleed when an alkaline fat-liquor is used subsequent to the dyeing.

Acid blacks are also combined with direct blacks to get good penetration; in this case, the addition of acid is omitted, the leather being entirely neutralized before it is blacked.

**Coloring chrome-tanned calfskins.**—When these skins are to be colored, they should be selected with care. Only perfectly sound skins free from lime spots, scars, and other defects, should be used. It is essential that the chrome tannage yields a full leather which is soft after it is dried, even if but lightly fat-liquored. Before any attempt at coloring is made, the leather should be thoroughly neutralized and washed free of acid and salts acquired during the tannage; and after the skins have been washed it is necessary that they be shaved and made smooth and clean on the flesh side.

Dyeing may be done in several different ways. The same procedure as given under dyeing sheepskins may be applied. The amount of color used will, of course, depend upon the depth of shade desired.

In dyeing with basic colors, the stock is mordanted with sumac, gambier or fustic, and fixed with titanium-potassium oxalate. A solution of the basic dyestuff is then applied. Acid colors are used on chrome-tanned calfskins in the same manner as given under chrome-tanned sheepskins. For bright shades possessing good penetration a combination of acid and basic color is sometimes employed.

Usually a drum is used so that a large number of the skins may be colored at one time, thus saving a great deal of time and labor.

**Dyeing vegetable-tanned calfskins black:** *Logwood liquor.*—For blacking leather, logwood extract in paste, solid, and liquid forms are employed.

When the paste is used, from 6 to 8 lb. for each 100 lb. shaved weight is dissolved in 40 gallons of water together with $\frac{1}{2}$ lb. of borax or sal-soda, and brought to boiling point. This liquor is very strong, and is usually diluted with water.

Hematin and other similar products are used in the proportion of about 3 lb. for each 100 lb. shaved weight to a barrel of water. The dye is first boiled a few minutes in a half barrel of water, which is then filled with water. From 1 to 2 lb. of borax may be added to the dye liquor. A few ounces of fustic paste or crystals boiled with the logwood serves to intensify the color.

The leather is first given the logwood liquor by running in the drum for 20 minutes, and then the striker, consisting of a solution of 1 per cent of iron sulphate and $\frac{1}{4}$ per cent of copper sulphate, is introduced and the stock run for 15 minutes longer.

To color vegetable-tanned calfskins a deep black, the use of titanium-potassium oxalate as a striker is recommended; 100 lb. of dry leather requiring from 8 to 10 oz. of the titanium salt. If the leather is not fat-liquored before dyeing, it should be washed, fat-liquored, dried, and finished.

*Dyeing with direct leather blacks.*—Methods of dyeing leather black by the application of special blacks, without the use of logwood, are of fairly recent origin. Leather black T B and T G are useful in blacking any kind of vegetable-tanned leather, either on the grain side only, or upon both the flesh side and grain. The color is a rich, permanent black. The dyestuffs are dissolved by mixing 2 parts by weight with 1 part by weight of acetic acid (30 per cent), and then pouring boiling water over it while stirring constantly, so that a solution of about 1 per cent results, which is diluted if necessary. The dyestuffs are applied in the customary manner, either by the staining process, or in a paddle or a drum.

**Coloring vegetable-tanned calfskins.**—For this treatment, basic and acid dyestuffs are used. The latter are applied with the addition of some acid, 4 parts of an acid color usually

requiring 2 parts by weight of formic acid, or 3 parts by weight of lactic acid. The acid, before it is given to the leather, should be diluted with 100 times its weight of water. The leather is first run in a drum with the solution of dyestuff, and when it has taken up most of the color, say in about 15 minutes, the acid is poured into the drum and the leather is run for 10 minutes longer.

The leather is frequently freshened up with sumac before it is colored. When this is done, it is likely to contain uncombined tannin, which causes uneven or cloudy coloring, so tartar emetic is used to prevent this. The leather is first drummed with sumac liquor. This may consist of a decoction of sumac leaves or powder, or of a solution of 1 lb. of extract of sumac in sufficient water at 100° F. for 4 dozen skins. The leather is drummed with the sumac for 20 minutes, after which, 8 oz. of tartar emetic, dissolved in water, is poured in, and the leather is run 20 minutes longer. The grain is thus cleared and prepared for the basic dye. No potassium dichromate or other setting agent is required, as the color will be fixed on the leather.

In the treatment of leather which has acquired a dark color from the tannage it is advantageous to bleach it before coloring.

In dyeing vegetable-tanned calfskins the same methods are employed as under vegetable-tanned sheepskins. The quantity of dyestuff used depends upon the depth of shade desired. As vegetable-tanned calfskins should be dried out before coloring it is customary to run them in an emulsion of turkey red oil prior to dyeing. They may then be shaved, dampened back, and colored with basic, acid, direct, or alizarine dyes.

**Coloring velvet or suede leathers.**—Coloring is done most satisfactorily with acid dyestuffs. The dye-bath is prepared in the usual manner, and $\frac{1}{4}$ lb. of potato starch is added for 100 lb. of leather to ensure evenness of color and cover imperfections. At the end of 20 minutes in the dye-bath, acidulate with $\frac{1}{4}$ per cent of sulphuric acid, rinse the dyed leather, set it out, and dry in the usual manner.

Finishing is done as follows: Dampen the skins with clear damp sawdust and stake; then buff them on the buffing machine and fluff lightly on the flesh. In place of buffing on the wheel, the skins may be lightly worked over with the knife by hand, finishing off by working over the grain with a very fine emery made up into a suitable pad. The latter method gives an even, velvety feel and appearance to the leather. The finishing touch is a brushing with a stiff brush.

For vegetable-tanned goods, which are to be stained on the flesh only, the buffing in the first stage applies, and when buffed, they can be treated as follows: First give the skins a coat of "clearing," made by dissolving 2 oz. of oxalic acid in 3 or 4 gallons of water. Allow them to level well by lightly airing, and then work over with a light coat of stain, using in the dyestuff solution 4 oz. of dextrine and 4 oz. of gum dragon in 8 to 10 gallons of solution. In staining this class of goods it is the rule to give first a weak coat to ensure a more even absorption of coloring matter, finally working up the shade required in the second coat. For producing good shades in light browns, the use of titanium-potassium oxalate will serve a useful purpose in obtaining a bottom which is really rich, using about 3 oz. of the salt to 100 lb. of leather, drumming the skins with the solution for 20 minutes, and then adding the color solution to the drum.

A light crutching and rubbing up the velvet on the colored side with a fine emery pad, or a light buffing on the wheel, finishes the leather. Coloring the skins according to the following method produces deep penetration of color: The leather is buffed dry and soaked. It is then dyed warm in the drum with acid colors, some ammonia being added at the beginning of this operation. According to the thickness of the leather, up to 5 per cent of dyestuff, calculated on the weight of the moist leather, is used. The skins are dyed for one hour, the sulphuric or formic acid, up to $\frac{1}{2}$ per cent, being added towards the end of the operation. The leather is then rinsed thoroughly, set out, oiled, dried, and finished in the

usual manner by moistening in damp sawdust, drumming in a dry drum and glazing or ironing on the grain side.

Black is produced by dyeing with 2 per cent of nerazine G, shaded if necessary with other dyestuffs, the acid being added after about an hour's dyeing, and the leather topped with 1 per cent of velvet black and some alum or acetic acid. It is then dyed 20 minutes, rinsed, set out, oiled, dried, and finished.

**Notes on ooze calf and Russia chrome leathers.**—Chrome-tanned calfskins are finished into several fancy leathers. The most important of these are the boarded-tan calf, chrome Russias, and ooze in black and colors. The skins for boarded-tan calf and chrome Russia are selected in the wet tanned condition and colored before they are dried out.

The skins for ooze leather are fat-liquored after tanning with an emulsion of egg-yolk and flour, and then dried; after which process they are sorted and colored. The fancy ooze colors according to the "Leather Manufacturer," can be made by bottoming with sumac or fustic extract and some mordant like sulphate of iron, tartar emetic, or titanium-potassium oxalate, then coloring with basic dyes; or by coloring with acid or diamine dyes, and sometimes topping with basic dyes. Some light shades are also made with pigments.

Black ooze is made with a combination of logwood, nerazine, or oxydiamine black and leather black, or with a combination of developed black and leather black. One process of making black ooze calf is as follows: The skins are sorted after washing out of the chrome tannage. They are next shaved and fat-liquored 30 minutes with 5 per cent egg-yolk and 10 per cent flour. The skins are then drained off, hung up, and dried. When dry, they are dampened in sawdust, staked, and buffed. They are then ready for dyeing. The skins must be buffed very clean so that after coloring they will not need a second buffing. The next operation is a thorough wetting in a drum with water at 140° F. The

skins are next dyed 30 minutes at 130° F. with $12\frac{1}{2}$ per cent diamine ooze black C R, then fixed 15 minutes with 5 per cent muriatic acid. The skins are next drained off and rinsed in cold water. They are then diazotized, running the first 5 minutes in 10 per cent muriatic acid; then add 5 per cent sodium nitrite, and run them 15 minutes, drain them off, and wash thoroughly.

The muriatic acid is given before the sodium nitrite because the latter has an alkaline reaction, which has a tendency to wash the black from the leather before it can be diazotized. The diazotizing must be done cold so that the nitrous gas will not escape easily from the solution.

The skins are now developed 15 minutes with 0.8 per cent phenylene-diamine dissolved with 1.6 per cent soda ash and 0.2 per cent betanaphthol dissolved with 0.2 per cent caustic soda. The two solutions are made separately, but are mixed before they are applied. The skins are then drained off and washed, and next topped with 2 per cent leather black and $\frac{1}{2}$ per cent acetic acid. The skins are then thoroughly rinsed off and fat-liquored 45 minutes with 2 per cent of soluble oil. They are then dried on hooks, dampened in sawdust, staked, dry-milled, and tacked out.

Chrome Russia leather and tan chrome boarded calf are colored in about the same manner. As the latter leather is glazed it is necessary to keep the colors lighter and yellower because the glazing makes them sadder and redder. These colors are usually made with basic dyes on top of a vegetable bottom, because they give very full, even shades. Acid and diamine colors which would be much faster to light can be selected.

**Dyeing chrome-tanned goat-skins:** *Dyeing with acid colors.*—The neutralized and shaved leather is fat-liquored and then rinsed in water at 120° F. Twelve gallons of water heated to 125° F. is used in preparing the dye-bath for 100 lb. of leather. The leather and the hot water are put into the drum. The solution of dyestuff without any addition

of acid is then poured into the drum while it is rotating and the leather is run for 20 minutes. If particular value is attached to a good penetration, 1 oz. or more of ammonia should be added to the dyestuff, but this is effective only where the skins have been completely neutralized.

At the end of the 20 minutes, the dye-bath is acidified by adding formic or sulphuric acid, preferably the former. Enough acid should be used to neutralize the ammonia, and in addition, 2 parts by weight of formic acid or 1 part by weight of sulphuric acid for every 4 parts by weight of dyestuff are necessary. After the color-bath has been thus acidified, the leather should be drummed 10 minutes to allow the dyestuff to become fixed.

The addition of some sumac or gambier liquor to the dye-bath after it has been acidulated improves the feel and fullness of the leather, and makes it easier later on to obtain a good glazed finish.

To remove any excess of acid which may be present in the leather after it has been colored, a solution of 4 oz. of sodium acetate crystals for each 100 lb. of leather should be added to the water in which the skins are rinsed.

Very full shades are obtained by first coloring with acid dyes and then topping with basic color. This is done by adding a solution of some basic color—2 oz. or more of dyestuff for 100 lb. of leather—as soon as by the addition of acid all of the acid color has been exhausted from the dye-bath. If this cannot be effected completely, the topping may be carried out in a fresh bath, in which case no further rinsing is needed.

The temperature of the dye-bath should be kept as high as possible during the process, not lower than 120° F. It is advisable to pass the skins through hot water before throwing them into the drum, or treat them in it to warm them thoroughly. The sumac liquor used with the solution of dyestuff is made by steeping from 12 to 16 lb. of sumac leaves, sumac powder, or sumac extract, in 10 gallons of hot water; 2 gallons of the decoction is used for 100 lb. of skins. Sumac

may, however, be partly or wholly substituted by gambier; that is to say, the liquor may be made of equal parts of sumac and gambier, or gambier may be used alone.

*Dyeing with basic colors.*—The method of coloring chrome leather with basic dyes generally used consists of mordanting it with tanning extract such as sumac, gambier, or combinations of these two; or gambier and fustic, the latter or osage orange also being often used alone. Dyeing may be done either before or after the skins have been fat-liquored. For the mordant, sumac is chiefly used for light shades, fustic or osage orange for tan and yellow shades, and gambier for the darker ones. A decoction of 4 to 5 lb. of sumac is sufficient for 100 lb. of leather. After having been treated with sumac, gambier, fustic or osage orange, the skins are dyed with basic colors. The dyeing period should last 15 or 20 minutes, and the temperature of the bath should be 125°. It is advisable to add the dyestuff to the leather in several portions through the hollow axle while the drum is rotating. The drum should not be stopped until the solution of color has been in at least 10 minutes, otherwise the leather may be spotted.

*Sumac mordant for basic and acid dyes.*—Chrome-tanned goatskins are nicely colored by carrying out the following instructions: Prepare a sumac liquor by using a decoction of 4 to 6 lb. of sumac leaves for 100 lb. of skins, or a solution of 20 oz. of extract of sumac; use at a temperature of 125° F., and drum the leather in it for 20 minutes. Then pour in 4 oz. of titanium-potassium oxalate dissolved in a little hot water for 100 lb. of leather, and let the drum rotate 10 minutes longer. Then drain the liquor out of the drum and run the skins in a solution of dyestuff, either basic or acid dyes being used, preferably the latter. The result of this method of coloring gives full and uniform shades of color. It is also good practice to apply the dyes first to the sumac-treated skins and the titanium salt afterwards. This gives clear, bright colors.

*Gambier mordant for tan shades.*—For 100 lb. of stock, use 2 lb. of gambier dissolved in 12 gallons of water at a temperature of 125° F. Drum the skins in this solution for 20 minutes. Then pour in 3 or 4 oz. of titanium-potassium oxalate dissolved in hot water, and let the drum turn 10 minutes longer. Drain out the liquor and color the leather with acid dye, or rinse it in warm water and color with basic dyestuff.

A liquor composed of equal parts of gambier and fustic is also an excellent mordant for shades of tan and brown.

*Process for tan and brown shades.*—Drum the leather for 10 minutes in a solution of 3 oz. of titanium-potassium oxalate; add 1 lb. of fustic crystals dissolved in boiling water and drum 10 minutes; pour in another solution of 3 oz. of titanium salt and drum the leather 10 minutes longer; wash the skins, drain, and dye them with phosphines shaded with Bismarck brown to the exact color desired; drum 20 minutes, then fat-liquor the leather—if not fat-liquored before dyeing—with a slightly alkaline fat-liquor, and finish as usual. Five ounces of liquid extract of fustic may be used for each dozen skins, or 1 to 2 lb. for 100 pounds.

*Clearing the grain of grease.*—Skins which have greasy grain may be cleared by being drummed 15 minutes in a solution of 1 to 2 gallons of lactic acid in 50 gallons of hot water; they are then rinsed and treated with sumac, gambier or fustic, and colored. The acid removes the surface grease and opens up the pores of the grain so that the mordant and dye may go in more deeply and more uniformly.

*Dyeing with fustic extract and direct or anthracene colors.*—Wood dyes, such as fustic extract, may be used with direct, or anthracene colors in the production of fast colors on chrome leather. The process is as follows: The leather is drummed for 30 minutes with the requisite quantity of fustic extract. The solution of dyestuff is then poured in and the drumming is continued for a half-hour longer. Complete absorption of the dyestuff is finally brought about by the addition of 2 or 3 oz. of acetic acid per 100 lb. of leather.

Color of superior fastness may be obtained by adding from 4 to 8 oz. of sodium dichromate to the color-bath before the acetic acid is added, and by working the goods at as high a temperature as possible, or from 150 to 160° F. The liquor is then drained out of the drum and the leather is topped in a fresh bath with basic dyestuff. The leather is fat-liquored either before the dyeing is begun or after topping with basic color. In the latter case it should be rinsed thoroughly before it is fat-liquored.

Light shades, such as gray, drab, champagne, beige, biscuit, etc., are obtained by using acid dyestuffs in the following manner: The neutralized leather is drummed with the diluted solution of dye (3 to 4 oz. for 100 lb. of leather) at a temperature of 130° F., for 10 minutes. The fat-liquor is then poured in and the leather is drummed for a half-hour. This method of working may be reversed by commencing with the fat-liquor and adding the dyestuff after some time, also by using both dyestuff and fat-liquor simultaneously. All that is needed to obtain complete penetration is to neutralize the leather completely and prolong the drumming correspondingly. If necessary, $\frac{1}{2}$ to 1 per cent soap may be added to the ordinary fat-liquor. It is usually advisable to add a decoction of from 6 to 8 lb. of sumac or a solution of 3 to 4 lb. of gambier to the bath after the fat-liquor has been exhausted by the leather, and allow the drum to rotate a half-hour longer. The leather is then rinsed and set out.

*Use of tartar emetic.*—Chrome-tanned leather, previous to the application of artificial dye, is usually prepared with some tanning extract, as already stated. When uncombined tannin remains on the grain of the leather imperfect coloring results, and to prevent such defect and fix the color on the leather some dyers use tartar emetic, which is a tartrate of antimony and potassium. The leather is run in the sumac, gambier, or fustic liquor, as the case may be, the required period, when tartar emetic dissolved in hot water is added to the drum and the leather is drummed 15 minutes longer. At the end of this

time it is rinsed in warm water and colored with basic dye, then rinsed again and fat-liquored. Two ounces of tartar emetic is generally sufficient for one dozen skins.

**Notes and suggestions.**—While fustic extract is used in coloring, it may be combined with the fat-liquor, and the two processes of mordanting and fat-liquoring performed at one operation, coloring being done afterwards.

When chrome-tanned skins are colored after they have been fat-liquored, more dye is required than when coloring is done previous to fat-liquoring. This is due to the fact that the fat-liquor prevents penetration of the dyes into the pores of the leather. On the other hand, when the leather is colored before it is fat-liquored, the hot fat-liquor removes much of the color and makes it difficult to get the exact shade wanted. Basic dyes have the advantage over acid dyes in that no acid is required to set the color. When acid dyes are used, the leather should be washed and freed from every trace of acid before it is fat-liquored. It is the custom to color and fat-liquor chrome leather before drying it out, as it is not practicable to color the leather by the usual methods after it has been dried. It is said, however, that the leather can be fat-liquored and dried, and then wet-back and colored with acid dyestuffs in a bath to which a quantity of sodium bisulphate has been added. The process is as follows: The acid dye is dissolved in boiling water. Bisulphate, equal to the amount of dye, is dissolved in hot water in a separate vessel. Half of the dye solution and all of the soda solution are added to enough hot water to drum the leather—12 gallons for 100 lb. of leather—the skins being drummed in the liquor for 15 minutes. The remainder of the dye is then added, the leather is drummed 30 minutes longer, then washed in warm water, set out, and dried. From 8 to 10 oz. of dyestuff is usually required for a dozen skins. This method of dyeing is said to color leather satisfactorily which has been dried after fat-liquoring.

It has been found that a better finish can be secured on

skins that have been given a light re-tannage with some vegetable tanning extract, either before or during the coloring process. Acid dyes are used successfully on such a bottom. A mixture of 2 per cent of fustic extract and $\frac{1}{8}$ per cent logwood crystals produces excellent results as a mordant. After having been colored with coal-tar dye on this bottom, the skins are drained, and treated with an acid fat-liquor or an emulsion of oil and egg-yolk. Some dyers use basic color on top of an acid color, which makes the color faster to the fat-liquor. Applying fustic and logwood first, then acid dyestuff, and topping with basic dye, is a good method of obtaining tan and golden-brown shades. Sulphuric or formic acid added towards the end of the process increases the depth of color. Formic acid is preferable to sulphuric acid, as the latter is liable to cause greasy spots by curdling the fat-liquor.

**Coloring with natural dyestuffs.**—A few practical instructions will now be given by means of which chrome-tanned goatskins can be colored desirable shades without the use of artificial dyes. Fast colors are obtained by using dyewood extracts, and the cost of the materials is less than that of coal-tar dyes.

*Light tan shade.*—Take the shaved skins and put them in the drum with 12 gallons of water heated to 125° F. In a clean pail, dissolve 2 lb. of fustic extract (lemon shade) in hot water. Start the drum, and then add the solution of fustic and run the skins in it for a half-hour. Then add 4 oz. of titanium-potassium oxalate dissolved in a little hot water, and let the drum run 15 minutes longer. The skins will then be found well colored, and should be washed and fat-liquored. The color, if not quite satisfactory, can be modified by the use of coal-tar dye.

*Dark tan shade.*—Run the skins in a solution of 4 lb. of fustic extract (red shade), at a temperature of 125° F., for 30 minutes, using 12 gallons of water for 100 lb. of leather. After that period, add without stopping the drum, 6 oz. of titanium-potassium oxalate dissolved in a little hot water. Allow the drum to turn 15 minutes longer, then wash and fat-liquor.

*Ox-blood shade.*—A desirable shade of ox-blood is produced in the following manner: For 100 lb. of leather, dissolve $2\frac{1}{4}$ lb. of hypernic extract, 2 oz. of logwood extract, and $\frac{1}{2}$ oz. of leather red by boiling in a few gallons of water; then add sufficient water to make 12 gallons of liquor, and use it at 125° F. Drum the skins in this liquor for 30 minutes. Then dissolve and add $4\frac{1}{2}$ oz. of titanium-potassium oxalate and allow the drum to rotate 15 minutes longer. The skins are then in condition to be washed and fat-liquored.

*Chocolate shade.*—For this color use $2\frac{1}{4}$ lb. of fustic extract (lemon shade), 10 oz. of hypernic extract, and 3 oz. of logwood crystals in 12 gallons of water for 100 lb. of skins. After the drum has been running 30 minutes, pour in 5 oz. of titanium-potassium oxalate dissolved in hot water. Run the drum 15 minutes longer, then wash and fat-liquor the skins.

**Dyeing chrome-tanned goatskins black.**—These skins may be dyed black in a variety of ways. The customary method is to dye them in a drum, using logwood extract and direct leather blacks, thus obtaining a full black in one operation, and fat-liquor them after they have been blacked. The skins should be thoroughly neutralized and shaved before they are dyed.

*Dyeing with hematin crystals or logwood and direct leather black.*—This is one of the most approved methods of blacking chrome leather. The pack of skins (100 lb.), is weighed and thrown into the drum with 12 gallons of water heated to 125° F. Dissolve 1 lb. of hematin or logwood crystals in boiling water and add a little ammonia. The liquor is poured into the drum through the hollow axle and the leather is drummed 15 minutes. Dissolve $1\frac{1}{2}$ lb. of direct chrome leather black C in boiling water and add the solution to the drum, and run the leather 15 minutes longer. The exhausted dye liquor is then drained out and the hot fat-liquor is poured in. After is has been fat-liquored, the leather is washed 5 minutes in warm water, set out, oiled, and hung up to dry.

*Dyeing with logwood, leather black, and titanium-potas-*

*sium oxalate.*—For 100 lb. of leather a solution of 3 oz. of oxalate is used, and the leather drummed in it for 10 minutes. A solution of 1½ lb. of logwood crystals, ½ lb. of chrome leather black, and 4 oz. of sal-soda in boiling water, is next added and the leather is drummed for 15 minutes. Then a solution of 3 oz. of oxalate is added to the drum, and the treatment is continued 10 minutes longer. The leather is then either washed, struck out and fat-liquored, or fat-liquored immediately after it is blacked, and washed afterwards.

*Dyeing with chrome leather black.*—The skins, neutralized and shaved, are fat-liquored and then thrown into the drum for blacking. A solution of 1½ or 2 lb. of chrome leather black C in 10 gallons of water is poured into the drum, and the leather is treated with it for 30 minutes. The temperature at the beginning of the process should be 125° F. To fix the dyestuff, 1 oz. of acetic acid may be added towards the end, but in most cases this is unnecessary. A black grain and a blue-black flesh are obtained when this method is employed. Logwood extract or crystals may be used with the direct black to increase the fullness of the leather. The logwood solution may be added along with the dyestuff or immediately afterwards. No striker or other medium is required, the logwood becoming fixed on the leather during the dyeing.

*Another method of direct blacking.*—The following process can be used if the flesh side is to be dark blue or blackish-blue. The leather is first dyed for 20 minutes at 125° F. in the drum with 6 to 12 oz. of chrome leather black C in 10 gallons of water; then ¾ oz. of acetic acid is added for fixing the color, and 10 minutes later 6 to 9 oz. of leather black T B or T G. The leather is drummed 10 minutes longer and then rinsed. Fat-liquoring may be done either before or after blacking.

*Blacking with logwood and iron liquor.*—For 100 lb. of leather, boil 3 lb. of logwood extract and 4 oz. of fustic extract, in 12 gallons of water, and add 1 oz. of ammonia. Drum

the skins 30 minutes, then drain off three-fourths of the dye liquor and pour in, after the drum is turning again, 4 or 5 oz. of iron liquor in 10 gallons of water. After a further drumming for 10 minutes, the liquor is drained off and the skins washed thoroughly in running water.

*Dyeing with logwood, potassium permanganate, and iron liquor.*—This process is used in the following manner: In the drum are placed 450 lb. of skins as they come from the shaving machine, and 30 gallons of water heated to 120° F., after which the drum is closed and started. Dissolve 2½ lb. of permanganate in 55 gallons of water at 120 F., and add 2½ lb. of muriatic acid of 21° Bé., this solution being run into the drum through the hollow gudgeon. After 10 minutes, stop the drum, open it, and allow the liquor, which is now spent, to run out. Close the drum again, and after re-starting, pour 2 gallons of iron liquor mixed with 45 gallons of warm water in through the hollow axle. After 10 minutes, stop the drum, and allow the liquor to drain out. Next dissolve 3 lb. of extract of logwood and 3 lb. of sal-soda in 45 gallons of warm water, and after the drum has been started again, add this liquor through the gudgeon. Allow the drum to run 10 minutes, then stop it, and remove the skins. The next step is washing the leather, which is now black; this is done in a drum or twister supplied with running water. After being washed 15 minutes, the leather is ready to be fat-liquored and dried for finishing.

The iron-liquor referred to can be purchased as black iron, or may be prepared by dissolving scrap iron in dilute commercial acetic acid. The liquor ready for use should stand at 10° Bé.; but any suitable ferrous salt of iron may be substituted.

The muriatic acid should always be added to the permanganate solution when all of the water required is present, and never to a hot concentrated solution of permanganate. It is claimed that a deep, rich, and more permanent black, besides other advantages, is economically obtained by using this

process, which was patented by William M. Norris, Princeton, New Jersey.

**Dyeing chrome kangaroo black.**—The same methods as given under goatskins may be applied to this class of leather.

*Yellow flesh and black grain.*—Where leather with a yellow back and black grain is required, the skins are treated with acid fat-liquor after they are tanned, and are then dried. Preparatory to flesh coloring, the leather is wetted in a tub of warm water and placed in a pile to soften. For 100 small and medium skins, ½ pail of sumac is scalded with hot water for 2 hours. The sumac, with 4 pails of water, made slightly acid with lactic acid, is put into a drum and milled 25 minutes, the temperature of the liquor being 110° F. After the skins have been drummed in the sumac liquor, the yellow dye is added, and the leather run in it for 10 minutes. For the dye, dissolve 1 lb. of yellow S or other basic yellow in ½ barrel of water, and use 3 or 4 pails of the solution for 100 lb. (dry weight) of leather.

After the leather has been colored yellow, dye the grain on a table or a machine with logwood and striker, or with a solution of direct leather black. Rinse the leather, set out the grain, oil it lightly, then hang up the skins to dry.

**Chrome-tanned ooze calfskins.**—The skins that are worked into ooze leather must be free from butcher cuts and have full flanks, but good grain is not essential. In almost every pack of skins there are some that have defective grain which are unsuitable for grain finish, and can be finished only upon the flesh side. Such skins can be sorted out after the pack has been tanned, or they can be selected after they have been de-haired, and tanned separately from the others.

One method of finishing the skins into ooze leather is as follows: The skins are treated with a suitable fat-liquor, and some substance is added to the same, which, during the subsequent drying, isolates the fibers of the leather in such a manner as to allow them to be soaked and softened without difficulty. For this purpose, dextrine, grape sugar, syrup,

etc., are used. The stuffed leather is dried and then buffed. Buffing is done either by running the flesh-side on an emery wheel or by slightly snuffing the grain. The snuffed leather is then drummed with warm water until it has regained its original softness, and is then colored with acid dyestuffs. During or after dyeing a somewhat larger quantity of gambier or sumac is added than is otherwise customary with chrome leather, in order to impart the necessary firmness to the leather. The nap of the skins is then raised by working the leather in a dry drum after it has absorbed some moisture by a treatment with wet sawdust. The coloring is done in the same manner as described for grain leather.

Another way to produce ooze leather is as follows: After shaving, 100 lb. of skins are run with 1 quart of pumice in a clean drum for 30 minutes; then the flesh side is cut on a wet wheel so that the fibers are uniformly fine over the entire skin. After this has been done, wash the leather thoroughly to remove all of the pumice. The skins are then in condition to be colored and fat-liquored, these processes being the same as for grain-finished leather.

If black leather is desired, drum the skins in a solution of Bismarck yellow-brown or some other direct yellow-brown, then drum with a logwood liquor which is slightly alkaline, and strike with acetate of iron or copperas (iron sulphate), and fat-liquor them, following this with direct leather black, fat-liquoring again, and then hanging the skins up to dry.

There are special ooze blacks on the market which produce good results. They dye direct without the use of a mordant or logwood.

For light skins, a fat-liquor of egg-yolk and sperm oil is suitable; and for both light and heavy skins, one made of olive-oil soap, neat's foot oil, and moellon degras is recommended. It is made as follows: 1 lb. of the soap is dissolved in 6 gallons of boiling water. To the solution is added 4 lb. of the oil and 2 lb. of degras, and the whole is boiled for 30 minutes. Next add water to make 20 gallons of liquor.

In a separate vessel dissolve 6 oz. of potassium carbonate, add this to the fat-liquor, and stir thoroughly. This quantity of fat-liquor is sufficient for 200 lb. of leather. Use it at 140° F. Drum the leather 40 minutes, and then let it drain until the next day. Strike out each skin; oil the grain lightly, and hang up to dry.

When dry, dampen and stake the skins, and before they are dry, put them into a dry wheel and run them 3 hours; then tack them out. When dry, stake them lightly and run the flesh side on a plush wheel, which is the finishing touch. Softness, freedom from spots, and smooth, uniform colors and fibers are the essential qualities of this leather.

Velvet or suede leather is finished from chrome calfskins in the following manner: The skins are taken in a dry or crust condition and are dampened with clean, wet sawdust in the customary manner. They are next fluffed on the flesh side, care being taken to avoid scratches with new or coarse carborundum or emery. The grain then receives a thorough grinding on the buffing-wheel, after the leather is perched or staked lightly. After buffing, the skins are given a coat of a solution of dextrine, potato starch, or Irish moss (kelp extract), and are then allowed to remain until the moisture has almost evaporated from them. Sufficient moisture should be left in the goods to keep them cool for the wheeling or fluffing on the grain, which follows immediately.

The next process is coloring; and for this a good drumming in warm water is necessary to soften the leather. Add 8 oz. of borax to 12 gallons of water, and drum the skins 20 minutes; then rinse them for a few minutes.

A treatment with sumac is necessary to impart firmness to the leather, 3 or 4 lb. of sumac extract in water at 125° F. being used for 100 lb. of leather, which is drummed 30 minutes. A solution of gambier is also suitable for the purpose. Drain the liquor out of the drum and proceed to color the leather with acid dyes. Prepare the dye-bath by dissolving the amount of color necessary in 15 gallons of hot

water, pour this solution into the drum while it is rotating, and run the skins 10 minutes. Then add 4 or 5 oz. of fustic extract (a tannin from a West Indian wood) in solution to the bath and let the drum run 20 minutes longer. Then acidulate the dye-bath by adding 3 or 4 oz. of sulphuric acid, or three times as much sodium bisulphate in 1 gallon of water, and let the drum run 15 minutes longer. The dyed leather is next rinsed well in lukewarm water, and then given a drumming with a solution of egg-yolk for 10 minutes; it is then rinsed, struck out, and dried.

Complete penetration of the dye is secured by adding 2 oz. of strong ammonia to the dye-bath, and prolonging the drumming to 40 minutes or even longer; the ammonia is then neutralized by using slightly more acid or soda than the quantity mentioned.

The finishing operations consist of dampening the dry skins and staking them, then buffing on the machine and fluffing lightly on the flesh side. In place of buffing, they can be worked over with a warm knife, and finished off by working over the grain with very fine emery made up into a suitable pad. This last method gives a beautiful, even, velvety feel, and fine appearance to the leather. The last touch is brushing with a stiff brush.

**Chrome bag and belt leathers.**—Black chrome leather with a printed or boarded grain is used to some extent in the manufacture of hand bags and traveling bags, and belts for personal use. The leather, when it is suitably fat-liquored and finished, is well suited for these purposes, as it is soft, durable, and waterproof. It must, however, be firm, clean, and free from grease. The sides are tanned in the same manner as for shoe leather, preferably in the one-bath process, but the leather is given less fat-liquor. It is desirable that the color penetrate through the flesh so that the edges will be black and not blue. Direct blacks are preferable to logwood for dyeing. The leather is fat-liquored and then dyed, or it may be run first in a solution of the dye to stain the

flesh, then fat-liquored and dyed on the grain by hand. The use of a direct chrome black with logwood produces a rich color, and gives a fuller feel to the leather than the direct black alone. It is also practicable to fat-liquor the leather while it is being dyed, drumming it first in the dye liquor and then with hot fat-liquor. The fat-liquor may be a solution of sulphonated oil or a mixture of such oil and neat's foot oil. Getting the leather too soft and greasy must be carefully watched as when it is greasy, the grease strikes through the linings and is easily perceptible, so the leather must be fat-liquored just enough to make it supple without being soft and stretchy.

The grain is boarded two ways, or printed with a box grain and then boarded. Belts made of this material are almost indestructible, and bags give great satisfaction as regards appearance and wear. The more novel the leather is made to appear the more it is liked, there being an unceasing demand for new things in these lines of leather goods.

**Dyeing chrome side leather.**—This is done quickest and most uniformly in a drum, the general practice. For the production of the shades of tan and brown usually in demand, acid and basic dye-stuffs are used. The acid colors may be applied direct to the chrome leather without a mordant, although most tanners prefer to bottom with fustic and titanium-potassium oxalate. The basic colors are always applied upon a tannin mordant or base.

*Direct dyeing with acid colors.*—The same method as given under goatskins may be applied to this grade of leather.

*Tannin mordant for basic dyestuffs.*—Coloring with basic dyes is effected by first applying a mordant of gambier, fustic or sumac, fixing with titanium-potassium oxalate or tartar emetic, and then dyeing to the shade desired with the proper dye.

*Red-brown shade.*—A popular shade of red-brown is obtained by applying 4 oz. of alizarine brown G, 4 oz. of alizarine yellow R extra, and 1 oz. of alizarine new yellow extra

for 100 lb. of leather. Dissolve the alizarine brown G by boiling in 8 gallons of water, then add 4 gallons of cold water, and use the solution at 160° F. Drum the leather in this solution for 15 minutes.

Meanwhile, dissolve the other dyes in 3 gallons of boiling water and pour into the drum. Let the drum run 15 minutes; then drain off the liquor and fat-liquor the leather. It is also beneficial to the color to add 1 lb. of extract of fustic dissolved in hot water to the drum after the second 15 minutes, and let the drum run another similar period. Then dissolve and add 2 oz. of sodium dichromate, running the drum 10 minutes longer. Wash and fat-liquor the leather.

**Dyeing chrome side leather black.**—One of the most approved methods of dyeing chrome side leather black consists of the application of logwood and direct chrome leather black. The wet shaved leather is weighed and thrown into a drum with 12 gallons of water at 125° F. for 100 lb. of stock. Dissolve 1 lb. of hematin in water at 125° F.; add 1 oz. of ammonia to the solution, pour the latter into the rotating drum and run the leather for 15 minutes. Dissolve 1½ lb. of chrome leather black in water at 140° F., and pour the solution into the drum. The leather is treated 15 minutes, and may then be drained and fat-liquored, or the fat-liquor can be added to the dye-bath at the end of the dyeing process, the drum being run a half-hour longer. The leather is then washed in warm water, set out, oiled with suitable oil, and hung up to dry. Other methods already described may be used equally well on side leather.

*Yellow leather.*—If yellow leather is required, the stock may be colored with gambier in the following manner: Boil 125 lb. of gambier in 20 gallons of water, add 1 pint of muriate of tin and 3 oz. of tin crystals, stir thoroughly, and fill the barrel with water. For 50 sides use 4 pails of this gambier liquor, and add 2 gallons of water, also ½ lb. of picric acid and ½ lb. of fustic dissolved in 3 gallons of hot water. Mix the color solution in a tub and use it at 90° F. Drum the leather in it for an hour.

**Coloring vegetable-tanned upper leather.**—Hides that have been tanned by a gambier, quebracho, or combination process can be finished in various ways. For black upper leather—glazed or dull—the following process may be carried out: The grains of sides split out of lime, bated, pickled, and tanned, or the grains of sides split after tanning and then re-tanned, are washed and pressed. They are then fat-liquored and dried. The dry leather is then wet-down and colored blue or blue-black as a foundation for the subsequent black. The grain is next dyed black with logwood and striker, or with a direct leather black applied by brushing on. The skin is then set-out smooth and hung up to dry; next dampened, staked, and trimmed.

Where colored leather is wanted, the leather is fat-liquored and dried; then treated with sumac and colored; or it may be fat-liquored after coloring, and then dried and finished.

For both black and colored leather, the author would recommend the use of sulphonated oil fat-liquor.

Where it is desired to dye only the grain black, leaving the flesh undyed, the use of direct blacks such as leather black T B and T G is preferred. For bright finish the bluish leather black T B is especially well suited; for leather which is to be finished dull, the deeper and somewhat more greenish leather black T G is preferable. Leather which is given a moderate polish by being rolled or brushed may be dyed equally well with either brand. No preparatory or after-treatment is required.

Blacking the grain side only is done by brushing the solution of dye into the grain, two coats being generally sufficient for the dry leather. The color solution consists of 1 lb. of the leather black and 8 oz. of acetic acid in 10 gallons of water, the temperature being maintained at 120 to 140° F., during the operation. The dye is mixed with the acid and enough boiling water is poured over the pulp to make a solution of the proper strength.

**Dyeing sealskins.**—The well set-out skins are placed in piles, one dozen in each, with the necks and butts running

one way, and are then dyed with the following materials:

*Blacking.*—A pail of good strong logwood liquor, to which a half cup of ammonia has been added, is heated to boiling point and applied to the skins with a brush. This is immediately followed by a solution of iron liquor and glue, prepared by pouring 1 gallon of iron liquor over ½ lb. of best glue; this is allowed to stand a few hours and is heated before use. This "floss," as it is commonly called, is put on the skins evenly and thinly, and rubbed in thoroughly. After blacking, the skins are laid face to face, covered up, and allowed to remain over night for the black to set.

They are then grained from angle-to-angle with a board covered with a piece of thin tin, perforated similar to a nutmeg grater. After these two "cuts" they receive another cut on the belly with a cork-board, followed by a cut straight up the skin; they are dried in a hot room, "emeried," and seasoned.

The goods may also be utilized for colors by soaking in warm water, running them through a weak acid-bath and dyeing in a paddle at 115° F. If acid dye is used, the goods can be dyed out of tan; if dyeing is effected with basic dye, the tannin should be fixed with tartar emetic. After dyeing to shade, wash in cold water and tack out, taking care that the goods are not dried too rapidly, a moderate heat being preferable. When dry, they are taken off the frames or boards, and the side that is to be faced is filled with a potato-flour paste, made by adding sufficient farina to water to form a stiff paste. When the paste is cold, add a little color and apply a good coat, after which tack on the frames.

**Dyeing pigskins.**—Dry the leather and store it away for a while to mellow. Then, if it is to be colored, dampen and clean the grain with borax followed by sulphuric acid. To do this, wash the leather for 15 minutes in a warm solution of borax. Drain off the solution and run the skins in a solution of sulphuric acid. Drum them in this solution, then wash and run them in sumac again. After having been rinsed they are in condition to be colored. When colored, give them a

light coat of cod oil and dry. Staking, boarding, and glazing complete the process.

If black leather with undyed flesh is required, the skins should be dyed on the grain side only by the staining method. A solution of 1 lb. of leather black in 10 gallons of water is recommended for this purpose. It is brushed on the grain, two applications being usually sufficient.

Pigskins are much used in plain russet finish. For this they need to be bleached according to the instructions given above. For inner-soling, the skins are oiled with a mixture of fish and mineral oils, and finished by rolling.

**Process for producing marbled suede leather.**—The following description covers a process of finishing the flesh side of leather so that it will have a mottled appearance and a velvety feel. Leather made in accordance with the directions given is soft and pliable and has a velvety surface, which is ornamental and adapted for use in making ladies' bags, for table covers, and for a great variety of articles for which a soft ornamented leather is desirable.

The skins are tanned as usual, and the flesh side is then subjected to the customary preliminary steps taken in the ordinary manufacture of suede or velvet leather, that is, shaving and then wet-wheeling, or subjecting it to the action of an emery wheel while it is wet. While still wet, the skin is laid on a table with the flesh side up, and is puckered or gathered into folds, this being preferably done by hand, and some dye is poured onto the flesh side.

The exposed portions of the skin will, of course, be exposed to the full action of the dye, while the portions within the folds or puckers will be more or less affected, depending upon the character of the fold. If the fold is a deep one, and the sides happen to be pressed closely together, the dye will not penetrate to any extent into the fold, and the surface of the leather within the fold will remain practically in its natural condition. Other portions of the skin, where the two sides of the fold are not pressed closely together, will be affected somewhat by the dye and will be partly covered, al-

though the color will not be so deep as at the parts entirely exposed. The skin is then buffed on fine emery, dried, and the flesh washed, which results in giving it the velvety surface desired.

**Pigment finish.***—Owing to the shortage of dyestuffs during the early part of the world war, tanners were forced to try other means for coloring leather, and somebody suggested the use of mineral pigments. The results were so satisfactory that the application of pigments at once became general. Even now that coal-tar colors are again available, many tanners prefer to continue using pigments.

In the coloring and finishing of leather by means of pigments there are two general methods of application. The first is employed for coloring splits and ooze leather, and consists of adding the pigment in the mill; while in the other method the pigment is applied by hand or machine after the leather has been mill-colored with artificial or natural dyestuffs.

*Mill coloring.*—This method is mostly applied to splits. The neutralized, washed, and fat-liquored leather is pressed or whizzed to remove excess of water, and is then placed in the drying wheel and run in the presence of hot air until dry, and then sorted for coloring. The splits are placed in the color wheel, and enough hot water is added to wet them thoroughly and uniformly. The dry pigment may be thrown into the drum and sufficient water to float the stock added, or the pigment may be mixed with water and added through the trunnion; but in either case the mill is run until all of the pigment has been absorbed. When this has taken place, the splits are removed from the drum and again dried in the drying wheel. After drying they are staked, trimmed, and sorted. The stock may be colored and fat-liquored at the same time without the intermediate drying, but better results are obtained by the method given. This method also permits a better selection for colors.

Any of the mineral pigments may be employed in the above

* This description was largely supplied by C. B. Kinney, a former student of the author, to whom he desires to give full credit.

process provided they are properly ground. Such colors as yellow ocher, chrome-yellow, chrome-green, iron oxides, zinc oxide, lithopone, burnt umber, and the like.

*The finish.*—Pigment finish has to meet a number of requirements—it must go on evenly without giving a painted appearance; it must withstand rubbing, boarding, and wetting; it must penetrate and have a fine appearance as regards brightness, luster, and evenness; and it must not injure the leather or natural break.

The first problem in making a finish is to get the pigment into suspension. There are a number of mediums in which the pigment may be ground, but the most commonly used is some form of soluble oil. The pigment is mixed to a thick paste with the oil and then ground in an iron or burrstone mill. Under ordinary circumstances 24 fluid ounces of oil will carry 15 ounces of pigment to form a satisfactory paste. After the pigment has been ground it must then be added to the finish. The nature of the finish varies with the results to be secured, and finishes are as numerous as the varieties of leather. They are made in the same manner as ordinary finishes, and consist of solutions containing one or more of the following: shellac, casein, glue, blood albumen, egg albumen, gum, beeswax, Japan wax, soap, Irish moss, flaxseed, and all of the other finishing materials.

When the finish is ready, the pigment is stirred in slowly. A solution of some coal-tar color is next introduced, either to shade or give fullness and brilliancy. A clear, brilliant and full color with pigment alone is impossible, as straight pigment shades are flat and dead. It is best not to use too much water, but use solutions of dye and then season the body by adding the pigment. When incorporating the pigment it is best to add a little of the finish to the pigment paste. This throws the pigment into a fine emulsion, which mixes readily with the main body of the finish. After mixing thoroughly and diluting to the proper consistence, the whole solution should be strained through a fine cheese-cloth, and it is then ready for application. A stirring machine should be used

at the table, so that the solution may be constantly agitated and thus prevent deposition of pigment.

*Hand seasoning.*—The stock is passed through a seasoning machine, dried out, and again run through the machine. For these two coats a solution of coal-tar color, as near as possible to the shade desired should be used. The leather is then thoroughly dried and glazed. It is then given two coats of the pigment finish, using a flat swab covered with fine plush. After each coat the leather is dried, and glazed after the second coat. In these two bottom coats the amount of pigment should be greater than in the subsequent coats. After glazing, the leather is smooth-plated and given three top coats, each top coat containing less pigment than the preceding one until the last coat, which should contain no pigment. The top coat should contain some albumen to give the required brilliancy. After the last top coat the leather is thoroughly dried, lightly staked, and smooth-plated.

*Machine seasoning.*—The leather is dyed on the machine, as given under hand-seasoning, but the stock is not glazed. Three coats of pigment finish are now applied on the machine and when the last coat is dry the sides are glazed. Three more coats are then applied, and when dry, the leather is again glazed. The same procedure as given under hand seasoning should be carried out in machine-seasoning.

*Full grain finish.*—If the finish is to be applied to full grain leather it must be of such consistence that it will be easily taken up by the stock and will not crack. The application is much simpler in this case than in the preceding ones, in that the dye coats are unnecessary. The only results required are an evenness of finish and a clear color. From 2 to 4 coats only are required, the leather being glazed after each application. For full grain leather hand seasoning is the most satisfactory.

**Blacking and stuffing chrome harness leather.**—The leather, re-tanned, and shaved, is in condition to be blacked and stuffed. There are two methods: either the leather may

be blacked and then stuffed, or it may be first stuffed, then dried, buffed, and bleached.

When the leather is blacked first and then stuffed, it is taken, a side at a time, set-out smooth on a table and blacked with logwood liquor and striker; then it is washed, run through a wringer, and put into condition for stuffing.

The logwood liquor is made of 6 lb. of logwood crystals and 2 lb. of borax in 50 gallons of water. The striker is made of 7 lb. of iron sulphate and 5 lb. of copper sulphate in 50 gallons of water, although any good striker may be used. The leather, after it has been wrung, is ready to be stuffed, 100 lb. of it requiring 10 lb. of mineral wax, 10 lb. of best stearine and 5 lb. of good hard grease. These materials should be boiled and thoroughly mixed, and applied hot to the leather in a warm drum. The leather is drummed 40 minutes, then placed in piles, covered up and left until the next day. It is then struck out on the flesh side, hung up until partly dry, and next stoned out on the grain. The grain then gets a light coat of cod-liver oil, and is again gone over with the stone and slicker. The leather is then hung up to dry.

The stuffing described above may be used, or a mixture of 60 per cent stearine, 20 per cent tallow, and 20 per cent mineral wax, heated to 190° F., 24 lb. being used for 100 lb. of leather. The leather is weighed and run a few minutes in the hot drum. The stuffing is then thrown in and the drum run 45 minutes. After lying in a covered pile over night, the leather is struck out on flesh and grain and hung up to dry. When it is partly dry, the grain is re-set, and the leather is then thoroughly dried. When dry, the scratches and imperfections can be buffed from the grain, and it is then ready to be blacked with logwood and striker. A sig (a seasoning of adhesive compounds) is necessary to prepare the leather for the logwood. When blacked, the leather is washed off, set-out, and hung up to dry.

*Finishing.*—This is done with mutton tallow and cod oil, 3 lb. of the former and 2 lb. of the latter being melted

together, and the grain given a good coat with it, which is thoroughly glassed in. The leather is then left in a pile for 24 hours, when it is re-glassed, this being the finishing touch.

In case a dry feel is desired, the sides are seasoned with a solution of blood albumen, isinglass, and nigrosine in logwood liquor, then dried and oiled off with hot paraffin oil, or with a mixture of paraffin and neat's foot oils. Sometimes a coat of starch decoction is applied to the flesh side.

By using 7 lb. of quebracho liquor, 70° bk., for each side, weight and solidarity are given the leather. Chrome-tanned harness leather made by the methods that have been described has greater tensile strength and is more waterproof than ordinary bark-tanned leather.

# CHAPTER XIV

## FAT-LIQUORING

In the production of leather of any kind, the use of oils, fats, waxes, or soaps, or a combination of these is absolutely necessary during some part of the manufacturing process. These materials are used either as part of the tanning process or are introduced to give strength and pliability to the product. The oils selected are chosen with a view of producing special results or of imparting certain characteristics to the leather.

A discussion of oils is not within the scope of this book, but for those who desire more information on the general topic, reference may be made to the "Manual of Industrial Chemistry," written by the author of this treatise on tanning. It may not be out of place, however, to mention a few of the salient points which may be of value to the reader.

Oils, fats, and waxes constitute a large class of substances which are of animal, vegetable, or mineral origin. True oils and fats are derived from animals, both terrestrial and marine, and from vegetable sources, and consist chemically of a combination of fatty acids with glycerine. The nature and proportions of the fatty acids present determine whether a substance is an oil or a fat, but there is no distinct line of demarcation. What is a solid fat in cool climates may be liquid oil in a warm climate, so that some authorities prefer to make no distinction between fats and oils, simply calling one class liquid and the other solid. Solid fats usually contain a larger proportion of stearine. Most natural oils, however, are mixtures of several fatty acids with glycerine. The chemical constituents of a fat may perhaps be better understood from the following formula:

$$(C_{17}H_{35}COO)_3C_3H_5 \text{ (stearine)}$$
$$(C_{17}H_{33}COO)_3C_3H_5 \text{ (olein)}$$
$$(C_{16}H_{31}COO)_3C_3H_5 \text{ (palmitin)}$$

In other words, the above combinations constitute the prin-

cipal ingredients of most oils, and the proportions of each determine whether it is liquid, pasty, or solid. In addition to these typical compounds, most fats or oils carry some other bodies which give them special characteristics. Depending upon whether the oils contain larger or smaller quantities of unsaturated fatty acids we have drying, semi-drying, and non-drying oils.

Any oil, when treated with caustic alkali, undergoes a change which is called saponification, meaning the formation of soap. For example, if we treat tallow, which contains a large amount of stearine, with caustic soda, we have the following reaction:

$$\underset{\text{stearine}}{(C_{17}H_{35}COO)_3C_3H_5} + \underset{\text{caustic soda}}{3NaOH} = \underset{\substack{\text{sodium stearate}\\ \text{or soap}}}{3C_{17}H_{35}COONa} + \underset{\text{glycerine}}{C_3H_5(OH)_3}$$

This sodium stearate is what we are familiar with as soap. The character of the soap is influenced by the quantity of sodium stearate which it contains; the more stearate present the harder the soap.

Waxes differ from oils and fats in that they are a combination of fatty acids with higher alcohols. They do not lend themselves so readily to saponification as oils, but when they do so saponify the resulting product is a soap and a higher alcohol. Certain oils have the property of combining with sulphuric acid, forming what is known as sulphonated oils, or soluble oils, a more complete description of which will be given later in the text.

Mineral oils are entirely distinct from true oils in their chemical composition, being a mixture of hydro-carbons which are incapable of saponification. These oils are derived mostly from petroleum, and are usually spoken of as petroleum or paraffin oils. These mineral oils range in fluidity from light mobile liquids to heavy wax-like substances.

Oils of the above-mentioned classes are used in the production of leathers either for fat-liquoring, oiling, or stuffing.

Their uses for various purposes will be seen in the following pages.

**Fat-liquoring process.**—This is a process of much importance in the finishing of leather. No matter how well tanned the hides or skins may be, if they are not properly fat-liquored they dry out stiff and lack that full, well-nourished feel that is so essential; the fat-liquor imparts to the leather the necessary fullness and softness. The process consists in treating the leather in a drum with a hot emulsion of soap, oil, and other ingredients, which is entirely absorbed by the leather. If given too much grease they work out too soft and cannot be finished satisfactorily. The fat-liquor should be a perfect emulsion; if it is not, the grain is likely to have a greasy feel and the colors a patchy appearance. Neat's foot, olive, castor, and sulphonated oils are generally considered the most suitable oils for fat-liquoring light leather; egg-yolk and soap being sometimes combined with them. There are also several prepared fat-liquors and oils obtainable which are of much value. Commercial fat-liquors are carefully prepared, blended and aged, and containing no excess of alkali they produce excellent results on both chrome and vegetable-tanned leather. Sulphonated oils require merely to be dissolved in hot water to be ready for use. The best way to use such oils, however, is to combine them with oil or grease, such as neat's foot or moellon degras. The sulphonated oil so used acts as the carrier and emulsifier of the other oils and greases.

Before being fat-liquored, the leather is sometimes pressed or struck out to rid it of the surplus water, which would retard the penetration of the fat-liquor; but as a rule the fat-liquor is applied to the wet stock immediately after coloring. A suitable drum is heated with live steam to a temperature of about 140° F. for chrome-tanned leather and 120° F. for vegetable-tanned stock. Whatever water there may be in it is drained out, and the skins are thrown in and drummed for 5 minutes to warm them. The hot fat-liquor is then poured into the drum through the hollow axle and the skins are drummed in it for 30 minutes, being then dipped into hot

water, placed smoothly over horses and covered up for several hours so that the grease may combine with the fibers.

*Fat-liquors for chrome-tanned sheepskins.*—After these skins have been neutralized, washed, and shaved, they are either dyed and then fat-liquored, or fat-liquored and dyed afterwards. Some tanners combine the two processes, first dyeing the leather in a drum and then running the spent dye liquor out and applying the fat-liquor. It is also practicable to add the fat-liquor to the dye liquor in the drum after the skins have assumed the desired color. The fat-liquor feeds and nourishes the leather. Sheepskins are naturally soft and do not require much fat-liquor; nevertheless, some grease and oil are required to impart to the leather the desired fullness and soft feel. When the fat-liquoring is a separate process, a suitable drum is heated with live steam, the leather is thrown in and drummed 10 minutes to warm it and make it more receptive to the fat-liquor. The fat-liquor is now poured into the drum through the funnel attached to the hollow axle and the leather is drummed with it for 30 minutes or longer, or until it has absorbed the oil and grease and left the water behind. After the process is finished, the leather is taken out of the drum, and if it was not previously colored, it should be rinsed in hot water, drained, and dyed; if it was colored before it was fat-liquored, the custom is to strike it out, oil the grain, and hang it up to dry. Any one of the following formulas may be used with the assurance that the leather will be fat-liquored in a satisfactory manner:

1. For 100 lb. of leather: 1 lb. of castile soap, 1 pint of neat's foot oil, and ½ lb. of egg-yolk. Boil the soap in 2 gallons of hot water; add the oil, and mix thoroughly. Then add cold water to make 12 gallons of liquor. When the temperature has been reduced to 120° F. by the cold water, add the egg-yolk and mix thoroughly.

2. For each dozen skins to be fat-liquored, use 1 pint of egg-yolk, ½ pint of olive oil, 4 oz. of castile soap, and 6 gallons of water. Chip the soap into the water and boil until it is dissolved; then stir in the oil. Boil the mixture of soap and

oil; cool down to 100° F., and add the egg-yolk. For glove leather, make a paste of 1 pint of flour and cold water and stir it into the soap, oil, and egg solution. Mix thoroughly, run it into the drum at 110° F., and mill the skins with it for 30 minutes.

3. A fat-liquor considerably richer than the foregoing is made of 2½ lb. of neat's foot oil, ½ oz. of potassium carbonate, ¾ lb. of potash soap, and ¾ lb. of sulphonated oil. Mix and use the same as No. 2. This fat-liquor gives a well-nourished, springy feel to the leather, and there is no danger of spew.

4. Chrome-tanned skins can be fat-liquored with egg-yolk and neat's foot oil. Such a fat-liquor is especially suitable for colored leather. For each dozen skins use 1 pint of egg-yolk and ½ pint of neat's foot or olive oil. Beat the two thoroughly together and add warm water. Use at a temperature of 125° F., and drum the skins with it for 30 minutes.

5. For chrome-tanned glove leather: 1 lb. of olive oil soap, 2 oz. of borax, ½ lb. of neat's foot oil, and 2 lb. of egg-yolk for 100 lb. of leather. Apply before dyeing at a temperature of 125° F.

6. For 200 lb. of skins, use soap, 8 oz.; olive oil, 2 lb.; treated cod-liver oil, 2 lb.; birch oil, 2 oz.; and potassium carbonate, 3 oz. Boil the soap, olive and cod oil in a few gallons of water, then add the birch oil. Stir the emulsion thoroughly, then add the potassium carbonate dissolved in a little hot water. Add enough water to make 15 gallons of liquor, and use at a temperature of 160° F.

7. A good fat-liquor for 200 lb. of heavy dull-finished leather is made of soap, 1 lb.; neat's foot oil, 3 lb.; moellon degras, 3 lb.; and salts of tartar, 4 oz. Boil the soap and oil in a few gallons of water, then put in the moellon degras and stir thoroughly. Dissolve the salts of tartar in a little water; add the mixture and stir again. Run in enough water to make 24 gallons of liquor and apply to the skins at 150° F.

8. The sulphonated oils now on the market are of value in fat-liquoring. The oil is dissolved in hot water and the leather is drummed with the solution either before or after

it has been colored. The oil can also be added to the dye liquor and applied to the leather in that form. It is generally best to pour it into the drum after the color has been taken up by the skins.

Neat's foot oil should not contain any solid fatty substance which is likely to separate at a low temperature and thus cause exudation, nor should there be any solid fatty acids in the soap. A small quantity of borax or sal-soda is often added to obtain a finer emulsion; and the use of castor oil, Turkey red oil, or castor-oil soap is advisable when very pliable leather is required. Fat-liquor should penetrate the leather easily and should not contain any ingredient likely to cause exudation or spewing. A greasy or sticky feel of the leather after fat-liquoring indicates insufficient neutralization or the presence of lime. Where leather is to be colored after it is fat-liquored it should, immediately after completion of that process, be dipped in clean, hot water, to remove surface oil. This rinsing in hot water clears the grain, so that the mordant and dye "take hold" more readily.

*Fat-liquoring chrome-tanned calfskins.*—After calfskins have been tanned into leather by a process of chrome tanning it is necessary to treat them with oil or grease in some form so that they may be finished into soft, well-nourished leather. The quality of the finished product depends largely upon how this process is applied, and what materials are used. Nothing that seriously affects the color or makes the leather greasy or spotted can be used. The skins can be fat-liquored either before they are colored or afterwards, the usual custom being to do the work before coloring in order that the fat-liquor shall not injure the color. Black leather, however, is usually fat-liquored after it has been blacked. Some tanners, in order to save labor, do not wash their leather after dyeing it; they simply drain off the spent dye liquor and run in the fat-liquor, and in some cases the dye liquor is not even drained off, the fat-liquor being added after the leather is colored. The oil and grease are employed in the form of an emulsion, which is readily taken up by the leather.

The skins are generally shaved before being fat-liquored; but some prefer to shave after blacking. When this is done, only half of the dye required for shaved leather is used, nigrosine or other color must be added to the fat-liquor to cover up the unevenness produced by shaving.

Sulphonated oils are of great value to the tanner of chrome calfskins. Combined with neat's foot oil and moellon degras, the sulphonated oil acts as an emulsifier and carrier of the others. The following fat-liquors can be used on black or colored leather with perfect safety:

1. Take $6\frac{1}{2}$ lb. of neat's foot oil and heat to about 160° F. Dissolve $2\frac{1}{2}$ lb. of potash soap in hot water, stir it into the oil, and mix thoroughly. When the mixture has cooled slightly, add $6\frac{1}{2}$ lb. of sulphonated oil and mix well. Three pounds of this mixture dissolved in 12 gallons of hot or boiling water will fat-liquor 100 lb. of leather.

2. A richer fat-liquor, which gives a better-nourished feel to the leather, is made of $12\frac{1}{2}$ lb. of neat's foot oil, $2\frac{1}{2}$ oz. of potassium carbonate, $3\frac{3}{4}$ lb. of potash soap, and 4 lb. of sulphonated oil. Heat the neat's foot and the potash to 160° F.; add the dissolved soap, and stir well; cool slightly and add the sulphonated oil, stirring the mixture thoroughly. Use 3 lb. of this mixture dissolved in 12 gallons of hot water for each 100 lb. of leather.

3. An excellent fat-liquor is made of soap, oil, and degras. For 100 lb. of leather use, fig or olive oil soap, 1 lb.; neat's foot oil, 2 lb.; moellon degras, 2 lb.; and caustic soda, 1 oz. Boil the soap in a few gallons of water until it is dissolved; then add the oil and boil the mixture for 15 minutes. Then stir in the moellon degras, adding the caustic soda dissolved in water. Add water to make 12 gallons of fat-liquor; use at 125° F., and run the leather in it for a half-hour

4. The following is a good fat-liquor for colored leather: Soap, $\frac{1}{2}$ lb.; olive oil, 2 lb.; treated cod oil, 2 lb.; birch oil, 2 oz.; and salts of tartar, 3 oz. Boil the soap until it is dissolved; add the olive and cod oils, and boil several minutes; then stir in the birch oil and the salts of tartar dissolved in a

little water. Add enough water to make 12 gallons of liquor, and use it at 125° F.

5. Castor-oil soap and castor oil make an excellent fat-liquor for colored skins. A half pound of the soap and $\frac{3}{4}$ lb. of the oil may be used in 10 to 12 gallons of water for each 100 lb. of leather.

6. Neat's foot oil and cod oil are used in another liquor, 1 pint of each being stirred together with 1 pint of a 10 per cent solution of soda, and the mixture added to a hot solution of 3 lb. of soap chips in 6 pints of boiling water; 5 or 6 lb. of the mixture is used for 100 lb. of the shaved skins.

7. For light-weight colored skins, a satisfactory fat-liquor is made of Castile soap, $1\frac{1}{2}$ lb.; neat's foot oil, $1\frac{1}{2}$ pint; egg-yolk, $\frac{1}{2}$ lb., for 100 lb. of leather. Dissolve the soap in a pail of hot water, then add the oil, and when cool the egg-yolk, and mix well. Make up to 12 gallons and use at 125° F.

8. One pound of fig or other good soap, 4 lb. of treated cod oil, 2 lb. of moellon degras, and 1 oz. of caustic soda is particularly suitable for dull-finished leather. Boil the soap; add the oil and boil again; then add the degras and soda and stir for 5 minutes. There should be 12 gallons of the liquor, used at 125° F., and the leather drummed with it for a half-hour.

9. A fat-liquor made according to the following formula is suitable for either black or colored leather, and is quite satisfactory: Olive-oil soap, 1 lb.; borax, $1\frac{1}{2}$ oz.; neat's foot oil, $\frac{1}{4}$ lb.; egg-yolk, $1\frac{1}{2}$ lb., for 100 lb. of leather. Boil the soap in 2 gallons of water; dissolve the borax in a little hot water, and stir it into the neat's foot oil; add water to reduce the temperature to 90° F., and stir in the egg-yolk. Make up to 12 gallons, and apply at a temperature of 125° F. The fat-liquor is usually absorbed by the leather in 30 minutes.

10. Sulphonated oil alone, or mixed with neat's foot, cod, or moellon, gives satisfactory results on chrome-tanned calf.

**Oiling the leather.**—When the fat-liquoring is finished, the skins should be placed smoothly over horses to drain several hours. They are next struck out on the grain side and oiled. The water should be pressed out of the leather before the

oil is put on so that the latter can quickly penetrate into the body of the skins where it will add strength to the fibers. For the oiling there is none better than neat's foot, which is used alone and also in combination with paraffin oil. For a bright finish, a mixture of 1 part neat's foot and 3 parts paraffin oil is sometimes used; for dull leather, equal parts of the two oils.

It is advisable to apply the oil hot to the leather, and avoid oiling the flanks, after which they are hung up to dry. It is best to dry them rather slowly in a moderately warm room with a good circulation of air.

**Fat-liquoring chrome-tanned kangaroo.**—1. An acid fat-liquor recommended for kangaroo leather is made of sulphonated oil and neat's foot oil. Mix 6½ lb. of the latter oil with 6½ lb. of sulphonated castor oil, and make a rich emulsion with water. Three pounds or less of this fat-liquor, diluted with 10 gallons of water at 140° F., is enough for 100 lb. of leather. The addition of ½ lb. of ammonia is recommended where there is a slight trace of acid in the stock.

2. A fat-liquor somewhat richer than the foregoing, which gives a well-nourished leather, is made of 12½ lb. of neat's foot oil, 2½ oz. of potassium carbonate, 3¾ lb. of potash soap, and 4 lb. of sulphonated oil. Dissolve the carbonate in a little hot water, and stir it into the neat's foot, and heat the oils to 160° F. Then add the potash soap and stir it thoroughly. Shut off the steam and add the sulphonated oil, stirring thoroughly until a perfect emulsion results. This fat-liquor gives a good feel, and the leather can later on be finished in dull or glazed.

3. This is also recommended: fig or olive oil soap, 1 lb.; neat's foot or cod oil, 2 lb.; moellon degras, 2 lb.; and caustic soda, 1 oz. Boil the soap in 6 gallons of water until it is dissolved; add the oil and boil 15 minutes; then add the moellon degras, and stir 5 minutes. The caustic soda, dissolved in 2 quarts of water, is added last. Enough cold water should then be introduced to make 12 gallons of fat-liquor for 125 lb. of leather.

4. The following fat-liquor and No. 3 are recommended for dull-finished leather: moellon degras, 3 lb.; and salts of tartar, 4 oz. Dissolve the latter in 3 gallons of hot water; then stir in the degras, and stir thoroughly for several minutes; finally adding enough water to make 12 gallons of liquor. Use at 140° F.

*Applying the fat-liquor.*—An approved method of fat-liquoring chrome-tanned kangaroo leather is first to dye the skins black and then wash them, pressing or striking out the surplus water. The clean drum is heated with live steam; the water is drained out, then the leather is thrown in and drummed a few minutes to warm it. The hot fat-liquor is finally poured in and the leather is drummed for 40 minutes.

All of the grease should be taken up by the leather, leaving nothing but clear water behind. Some tanners use the following method: The leather and a quantity of hot water are put into the drum and run 10 minutes. The drum is then stopped and the fat-liquor in a slightly concentrated form is poured in, and, mixing with the hot water, accomplishes its purpose. It is also customary to add the hot fat-liquor to the dye liquor after the color has been exhausted. Finally the leather is placed over horses to drain at least 12 hours; it is then set out, oiled on the grain with neat's foot and glycerine, and hung up to dry.

**Fat-liquors for chrome side leather.**—The fat-liquoring of chrome-tanned grain leather may be done before coloring or blacking, or immediately afterwards. The preferred method is to fat-liquor leather before it is colored, and black leather after it has been dyed. The methods given under chrome calf and kangaroo leather will work equally well on this class of stock.

**Fat-liquoring vegetable-tanned side leathers.**—In the finishing of sides into dull and glazed boarded grain leather, imitation kangaroo as well as black and colored Russia leather, a not uncommon practice is to give the goods two applications of fat-liquor, one before and one after coloring. Both fat-liquors may be sulphonated oil, or the first may be a solu-

tion of the sulphonated oil, and the second an emulsion of oil, soap, and degras. The procedure is as follows: After the leather has been split, re-tanned, pressed, and shaved, it is sammied and then weighed for the first application of fat-liquor. The drum is heated with live steam to 125° F., and the leather put in with a small quantity of hot water, and drummed until it is filled and the moisture evenly distributed, the fat-liquor being thus rapidly absorbed. Another way to moisten the leather is to dip it into warm water and place it in piles until it is softened throughout, this being less likely to "pipe" the grain than dampening in the drum. An excess of water in the drum or in the leather must be guarded against, as it prevents absorption of the fat-liquor. After having received the first application of fat-liquor, the leather is rinsed off in clean water to free it from particles of leather fiber and fleshings, which, containing oil, are liable to spot the leather while it is drying. Previous to being hung up to dry, the leather should be placed on a horse for a few hours to allow the fatty matter to penetrate.

When leather is given two applications of fat-liquor, the first treatment should be at least half of the whole quantity used. Colored leather can be given no better fat-liquor than sulphonated oil, used alone or combined with neat's foot or degras, such fat-liquor being also good for black leather. A thoroughly emulsified fat-liquor of soap, oil, and degras is also suitable, while some tanners prefer to buy a commercial fat-liquor rather than make it themselves.

Glazed and boarded grain leather is colored blue on the flesh side before the second application of fat-liquor, and blacked upon the grain afterwards; flesh and grain may also be dyed at one operation if desired.

Colored Russia leather is usually bleached, mordanted, and colored previous to the second application of fat-liquor.

When dry from the first application of fat-liquor, the leather is dampened and colored, then dried and dampened again for the second fat-liquoring. Imitation kangaroo and dull grains are usually yellow-backed before the second ap-

plication of fat-liquor. After it is fat-liquored, the leather is again dried for finishing. Kangaroo calf and sides are sometimes fat-liquored and dried, then yellow-backed, grain-blacked, dried, and finished. The leather may be washed after re-tanning; pressed and fat-liquored; dried, and then colored and finished.

Quebracho, gambier, and combination-tanned leather can be handled satisfactorily in the following manner: When the re-tanning is completed, the sides are washed and pressed to remove surplus liquor. After pressing, the leather is shaved and fat-liquored. In some cases it is drummed with sulphonated oil and dried before it is fat-liquored, this being a good method to follow in finishing colored leather. A drum is heated with steam to 100° F., and 1 gallon of sulphonated oil is used for 150 lb. of leather, weighed after pressing and shaving. The leather is drummed with the oil for a half-hour, then hung up and dried. After drying, the leather is weighed, dampened with warm water, and placed in piles to soften. It is then put into the drum and run with just enough water to soften it uniformly, when it is in condition to receive the fat-liquor. This method is entirely practicable and satisfactory, but some tanners omit the oil and fat-liquor the leather after it has been drained and pressed.

To fat-liquor the leather, the drum should be heated to 125° F. with live steam, and the leather drummed in warm water until it is soft and full. The fat-liquor should be given to the leather in portions of 1 to 2 gallons at a time through the hollow gudgeon, and after all of it is in the mill, the leather should be drummed 40 minutes. After being taken out of the mill, the leather should be rinsed in clean warm water, drained, and dried. When dry, it may be colored blue on the flesh and black on the grain, or yellow upon the flesh and black on the grain; or it may be colored any shade desired, dried, and finished with smooth, boarded or printed grain, or into imitation kangaroo leather.

The following fat-liquors have been used in tannery practice, with good results:

*Fat-liquor formulas.*—1. Boil 25 lb. of potash soap in 25 gallons of water until it is dissolved. Add 50 lb. of English sod oil and 6 quarts of neat's foot oil to the solution, and stir for several minutes. A few pounds of moellon degras may also be added. Enough cold water is next introduced to make 50 gallons of liquor, and 20 gallons of this liquor suffices for 100 lb. of dry leather which has been run in sulphonated oil previous to being dried. The exact quantity to use, however, varies with the tannages, the quantity stated being the maximum; but a smaller quantity will in most cases produce the desired result.

2. Five pounds of soap and one gallon of moellon degras boiled and made into a fat-liquor with a half barrel of water is sufficient for 400 lb. of leather. It may be applied to the leather immediately after tanning, or the leather may be drummed with a little sulphonated oil and dried before it is fat-liquored.

3. A good stuffing for imitation kangaroo and dull-printed sides is made of 12 lb. of cod oil to each 100 lb. of leather, dried after re-tanning, and weighed after it is dampened. Use at 130° F. Pack the leather down over night to harden; then set it out by hand and hang it up to dry. When dry, buff off the grain, trim, and stake the leather; then color the flesh yellow, and black the grain and finish the leather.

4. For hemlock, quebracho, gambier, and combination-tanned leather, the following fat-liquor is recommended: 10 lb. of soap, 4 gallons of neat's foot oil, and 10 lb. of degras to a barrel of liquor. Use at 125° F., preferably after coloring; then set the leather out, oil the grain, and hang up to dry. The leather, dried after re-tanning, is dampened, colored, and then fat-liquored, when the grain is struck out and oiled with neat's foot, and the sides are then tacked on frames to dry. Ten gallons of this fat-liquor is sufficient for 25 sides of 20-foot 4-ounce leather. It is best to use the liquor after the leather has been dyed black, or colored.

5. For bright printed or boarded grains, another suitable fat-liquor is 12 lb. of pure cod oil, 2 lb. of French degras, and

2 gallons of thin soft soap for 100 lb. of damp leather. Apply at 125° F. The leather, after being re-tanned, should be drummed for an hour in warm, strong sumac liquor; then rinsed, scoured on both sides, and hung up to dry. When dry, it is dampened and fat-liquored, set out, and a light coat of oil applied to the solid parts of the flesh side. The leather should be set out very hard on both sides, since the tighter it is set the finer and more even the grain will be when the leather is finished. When dry, the leather is dyed black, dried, staked, and finished.

**Fat-liquoring vegetable-tanned calfskins.**—The fat-liquors described under side leather are suitable for quebracho, gambier, hemlock, and combination-tanned calfskins; and can be applied to the leather immediately after it is tanned, or later, after it has been dried and colored.

Fat-liquoring is one of the most important processes in the manufacture of calf leather. Only the best grades of materials should be used, so that the leather will not be greasy, gummy, or liable to spew after it is finished. Sulphonated oil unites with the fibers of the leather and does not decompose in the leather; it also prevents greasiness and darkening of the grain.

From the scientific point of view there is yet a great deal unknown regarding the action on leather of those emulsions of oil and soap which are technically termed fat-liquors. As now used on many varieties of bark and combination-tanned leathers, fat-liquor is a development of chrome leather manufacture. Indeed, it is no exaggeration to say that the success of the chrome leather industry was dependent upon the discovery and application of fat-liquors; and even today the use of a proper fat-liquor is necessary for the production of a marketable product.

To a considerable degree, the formulas for various fat-liquors are among the most carefully guarded secrets of a leather manufacturer; yet in the main the composition and method of preparation of a good quality of fat-liquor has become well known. Practically, a fat-liquor can be defined

as an emulsion of oil and water, usually containing soap and frequently other emulsifying agents. Its purpose is to fill or nourish the leather and keep it from drying hard or brittle.

Although the claim has never been put forward, Robert Foerderer, the inventor of "vici kid," the first merchantable chrome leather, is accredited as being the real inventor of the emulsified fat-liquor; yet according to all evidence, it was the use of the fat-liquor which made vici leather far superior to the products of other leather manufacturers. When the knowledge concerning the use of emulsion of oil began to leak out, other manufacturers then started to make good chrome leather.

Having described the methods for producing fat-liquors, it will perhaps be well to consider their general constitution and the properties of their ingredients. An emulsion is a mixture of liquors that are mutually insoluble, but which are so mixed that fine particles of one are suspended in the other. The term is usually, although not necessarily, applied to mixtures of oil and water. Milk is often cited as the most perfect of emulsions. In order that an emulsion may be at all permanent, it is generally necessary that a third substance, called an emulsifying agent, be present. Such agents act by increasing the viscosity of the one liquid in which the fine particles of the other liquid are suspended to such a degree that the tendency to separate into different layers is largely overcome. In the case of milk, the casein, or milk albumen, acts as an emulsifier. In the familiar example of cod-liver oil emulsions of the pharmacy, the agent used is gum acacia or gum arabic. For leather manufacture it has been found that neither the casein of milk, nor gum arabic, nor indeed any other gum acts suitably as an emulsifying agent in fat-liquors. Primarily, they make trouble by perceptibly stiffening and harshening the leather, and then their power to increase viscosity diminishes rapidly with a slight increase in temperature. Soap has therefore become largely used as the emulsifier in the preparation of fat-liquors. Regarded simply as such, soap is not especially effective, but it has the extremely important advan-

tage, that is, provided the right kind of soap is used, that it is absorbed by the leather and does not injure it. To increase the efficiency of soap, or to replace it, two other emulsifying agents are used, namely, egg-yolk and sulphonated oils. The former is itself an emulsion, and the emulsifying agent in it is known as vitellin, an albumen considerably resembling casein. Presumably, because the proportion of oil and albumen in the egg-yolk to the water contained in it is greater than in milk, it can be used in relatively greater proportion; egg-yolk is therefore much more efficient in a fat-liquor than milk.

*Sulphonated oils.*—The subject of sulphonated oils is a large one and can be only briefly considered here. The best known of these is Turkey red oil which is largely used in the textile industry, especially in the dyeing of Turkey reds, hence the name. It is made by the action of sulphuric acid on castor oil. Its manufacture requires considerable care, and it is best made on a large scale in factories specializing in its production. Inasmuch as leather manufacturers using it have generally desired to keep that fact secret, they have endeavored to manufacture it for their own use rather than purchase it from an experienced maker, but such manufacture is usually attempted with imperfect apparatus, as well as inadequate knowledge. In the first place, castor oil is practically the only oil that can be sulphonated in the true sense, because the principal fatty acid in castor oil is ricinoleic acid, an unsaturated acid. This does not mean that other oils than castor cannot be treated with sulphuric acid, and some sort of a product obtained; nor should it be understood that it is impossible to sulphonate fatty acids other than ricinoleic acid. For example, the fatty acids of linseed oil are largely unsaturated, but unless extraordinary precautions are taken to cool the mixture of acid and oil, the reaction is so violent that what is known as secondary reactions take place and the fatty acids are largely destroyed.

The tendency of linseed oil to become resinous does not recommend it as a good leather lubricant. The more com-

mon practice is to treat oils, for example, neat's foot and tallow, whose fatty acids are principally acids of the oleic acid class. Oleic acid sulphonates only at a high temperature, and when an attempt is made to sulphonate one of the oils consisting largely of this substance, no sulphonation results; but the oil is simply broken up by hydrolysis and separates into its constituent parts, namely, fatty acid and glycerine.

*Casein.*—This has been employed as an emulsifying agent, but the fact that it is soluble only in alkaline solutions, makes its use objectionable. Also the liability of casein solutions to putrefy is a disadvantage, especially as the usual antiseptics precipitate it. Probably the most satisfactory preservative for casein solutions is white arsenic, only a very small quantity being needed, and so little arsenic remains in the leather that no objection can be raised to its use. One part of arsenic to two thousand parts of fat-liquor is a proportion that has been used with success.

*Egg-yolk.*—This, as has been stated, is a valuable constituent of fat-liquors. It is itself an emulsion in which an albumen similar to casein is the emulsifying agent. Probably one reason for the superiority of egg-yolk to casein is that, in the case of the latter, the natural emulsion is broken up, while the former is used in an unchanged state. There is a sufficient excess of albumen in egg-yolk over that required to emulsify the natural oil it contains to make it suitable for holding large proportions of other oils in a state of emulsion. It is for this purpose that it is valuable in fat-liquors. Unfortunately, some dealers in the material add other oils to the egg-yolk, which while not necessarily deleterious to the fat-liquor, they reduce the emulsifying power of the egg-yolk, and so are rightly considered an adulteration. Still more reprehensible is the practice of adulterating egg-yolk with emulsions of oils and casein, which are colored by aniline dyes. An easy test is the addition of a small quantity of ammonia to one portion of a suspected sample, and a little acetic or muriatic acid to another. If either the ammonia or the acid produces a decided color-change in the egg-yolk,

it indicates the presence of an aniline yellow, and is presumably an adulterated product.

*Potash soaps.*—These are preferably used as the soap constituent of fat-liquors. The reason for this is that they are soft soaps, that is, have a lower melting point than the hard or soda soaps. The objection to the high melting point—or to express it another way, the low solidifying point—of the soda soaps is that it causes white specks or soap crystals to form in the leather, which is one variety of the familiar spewing, an especially annoying defect in finished leather.

While all of the potash soaps are softer than the corresponding soda soaps, that is, those made from the same oils or fatty acids, one prepared from a hard, solid fatty acid will be nearly as hard as a soda soap made from a liquid fatty acid such as oleic acid. Also, if a soda soap is made from a liquid fatty acid, and a large percentage of water is allowed to remain in it, it will closely approximate the appearance of a potash or genuine soft soap. A simple drying test will, however, serve to distinguish the true from the false. In order to appear soft, a soda-soap must contain a high percentage of water, which will evaporate and the soap remain behind hard and dry if a small sample is exposed a few hours to gentle heat in a shallow dish. Potash soaps, on the other hand, will not dry out hard unless made from hard fat.

*Fig soap.*—A soap which has had much vogue for fat-liquor purposes is the so-called fig soap. It was originally a potash soap made from olive-oil foots. Much of the fig soap on the market is made from a mixture of olive-oil foots, cotton-seed oil, and tallow, and in appearance is much superior to that made exclusively from olive-oil foots.

For practical use, a soap is probably better made in the old way, as the hard stearic acid soaps (from the tallow) will crystallize in the leather and cause spewing.

The use of rosin oils must be especially avoided. These oils are obtained by the distillation of rosin, and while they are saponified, the products so formed have but few of the properties of ordinary soaps, and are unsuitable in fat-liquors.

The free fatty acids of rosin oils are objectionable as they oxidize and become resinous or gummy. Some sulphonated rosin oils have been offered for fat-liquoring purposes, but from theoretical considerations there is no reason to suppose that they will have sufficient efficiency to replace castor-oil compounds. A final word in regard to fat-liquors is the question of alkalinity or acidity. The first fat-liquors were essentially alkaline, on account of their large soap content; while the sulphonated oil compounds have an acid nature. If alkaline and acid fat-liquors are mixed, as frequently has been the case, the possible good effects of either when used separately are nullified.

The effects on colors should also be considered, and it should be especially remembered that an acid fat-liquor has much less effect on colors than one which is alkaline or contains a considerable quantity of soap.

**How to make and use sulphonated oils.**—A sulphonated oil is one that has been subjected to the action of sulphuric acid. The oils that can be sulphonated are castor, neat's foot, olive, cod, corn, and a few other saponifiable oils. Those that have been treated by the process of sulphonation have come more and more into use in the manufacture of heavy and light leathers. They are especially useful in fat-liquoring vegetable and chrome-tanned leather.

During the process of manufacturing sulphonated oil, the acid must be added to the oil very slowly; the oil should be thoroughly stirred while the acid is being added to it and also while it is being washed out. To obtain the best result, the oil must be chilled while it is being acidified. The following instructions will enable anyone to prepare a usable sulphonated oil: Take a barrel and saw it in two parts just below the two hoops near the top. This makes a tub of convenient size. Then put a 15-gallon crock into the tub and surround it with cold water. If the water is not below 60° F., add ice to lower its temperature, as it must be cold enough to chill the oil. Put 6 gallons of castor oil into the crock and stand over night to become thoroughly cool.

The next morning carefully pour 6 oz. of 66° Bé. sulphuric acid into the oil, and stir for at least 5 minutes after the acid has been added. Three hours later introduce 6 oz. more of acid, taking care to add it slowly and to stir thoroughly. Four hours later stir in another 6 oz., and two hours later 6 oz. more should be added with careful and thorough stirring. The next morning add 6 oz. of acid to the oil, and every 3 hours thereafter add 6 oz. until 24 oz. have been added on the second day.

On the morning of the third day take a clean barrel, and put a wooden spigot into it as near the bottom as possible. Place the barrel on a box or a block so that it will be 6 or 8 inches off the floor. Pour the acid-treated oil into the barrel and fill the latter two-thirds full of luke-warm water. Add 30 lb. of salt to the water and oil, and stir for 15 minutes. Repeat the stirring every half-hour for 5 hours; then allow the oil to rise to the top, open the spigot, and let the salt water run off until oil begins to show. Close the spigot and fill the barrel with warm water as before; then add 24 lb. of salt and stir for 15 minutes. Allow the oil and salt water to stand again over night, then draw off the water as before, and fill the barrel again with water, adding 18 lb. of salt, stirring as before. Draw the water off again and fill the barrel with warm water and put in 15 lb. of salt. Stir thoroughly for 10 or 15 minutes, and allow the oil to stand over night. The next morning draw the water off, and the oil that remains in the barrel is ready for use. In order to get a satisfactory product, the oil must be well stirred when washing out the acid; and the acid must never be put in fast enough to burn the oil.

To keep the oil, add a little water to it—about twice its own weight. Before adding the water, stir in enough concentrated ammonia to neutralize whatever acid there may be in the oil, also to carry it to the alkaline side.

Neat's foot oil and cod-liver oil may be combined and sulphonated in the following manner: Mix 30 lb. of neat's foot and 20 lb. of cod in a 20-gallon crock standing in a tub containing cold water. Add ice to the water to lower the tem-

perature below 65° F. Put the oil in the crock before closing down for the night, and in the morning it will be chilled.

For the 50 lb. of oil, use 88 oz. of sulphuric acid, dividing it into four equal portions. At about 8 a. m. pour one portion of 22 oz. of the acid very slowly into the oil, stirring while it is being added and continue for 5 minutes afterward. This should take about 15 minutes. Allow the oil to stand until 5 p. m. Then add another portion of the acid, stirring thoroughly as in the morning. Let the oil stand until the next morning; then add another portion of acid as before. At about 5 p. m. on the second day add the last portion of acid, stirring thoroughly as before, taking 15 minutes. On the morning of the third day, the acid-treated oil is in condition to be washed. Use a large barrel or tub holding 100 gallons, provided with a spigot, as mentioned above. Put the oil into the tub or barrel, and add enough water at 100° F. to fill the tub nearly half full. To the water add a pail of Glauber's salt and stir thoroughly, then add more water until the tub is nearly full. Allow this to stand until towards evening of the third day, then open the spigot and let the water run off. Close the spigot and fill the tub as before with warm water, and add a little less than a pail of Glauber's salt. Allow the mixture to stand until the next day, and then draw off the water the same as before. Fill up the tub again with warm water and 1¼ pails of common salt. Stir the oil and the water thoroughly, and allow the mixture to stand 12 hours. Then draw off the water and fill the tub again nearly full with warm water, and add 1½ pails of salt. Stir the oil well, and let the mixture stand until the next day. The water should then be drawn off, when the oil is ready for use.

A method which is used extensively and saves considerable time in washing consists in treating the sulphonated oil with a volume of water as indicated under washing, and to the water add sodium carbonate in place of the salt. The sodium carbonate at once combines with the sulphuric acid, forming sodium sulphate or Glauber's salt. The oil is thus neutralized, separated, and washed in one operation. Care, of course,

should be taken not to add too great a quantity of the alkali, otherwise there would be danger of saponification.

**Sulphonated oil on chrome leather.**—When the oil has been properly treated with acid and washed, it dissolves readily in hot water. When using, it is dissolved in water and the leather is drummed with the solution; 100 lb. of chrome leather may be fat-liquored with 4 to 6 lb. of the oil dissolved in 12 gallons of water at 125° F. The drum used for the purpose should be perfectly clean, and the leather warmed in a hot drum before it is given the fat-liquor. The exact quantity of oil to be used must be determined by the operator, and depends upon the degree of softness desired. Drum the leather in the fat-liquor for 30 minutes; then take it out and rinse it off in hot water to remove the oil from the surface. This washing is necessary when the leather is colored after fat-liquoring. If colored before fat-liquoring, rinse the leather, let it drain a few hours, strike it out, and hang it up to dry.

The best results, however, are secured when the sulphonated oil is combined with neat's foot oil or some other fat-liquoring material. Used in this way, it emulsifies the other oils and greases and carries them into the leather. When neat's foot or moellon degras is used with the sulphonated oil, the leather becomes lubricated internally, and has, when finished, a full, well-nourished feel.

**Sulphonated oil on vegetable-tanned leather.**—Vegetable-tanned skins may be fat-liquored with a solution of the sulphonated oil, with a mixture of such oil and mineral oil, with a mixture of sulphonated oil and neat's foot oil, or with a mixture of either sulphonated cod oil or sulphonated neat's foot oil and mineral oil. Of these combinations, the best is undoubtedly the mixture of sulphonated castor oil and neat's foot oil. The emulsion can be given to the leather immediately after tanning and before the skins are dried; it can also be brushed on or mixed with the tanning liquors toward the end of the drum tannage. Bark and extract-tanned leather, after it has been split and re-tanned, may be fat-liquored with a mixture of fish oil emulsified with sulphonated castor or

neat's foot oil. The mixture of oils can also be added to the re-tanning liquor in the drum, thus giving fullness and a soft feel to the leather.

**Sulphonated oil on sole leather.**—Another important use for sulphonated oils is in the extracting of sole leather. When sole leather is re-tanned in the drum it is of great advantage to add to the liquor mineral oil to which sulphonated oil has been previously added. This sulphonated oil is soluble in water, with which it forms a more or less thick paste, and mixes with mineral oil. The presence of the sulphonated oil enables the mineral oil to penetrate the leather in small quantities, and, without destroying its firmness allows it to retain a certain interior humidity. The presence of the mineral oil and of the sulphonated castor oil has also another object, namely it facilitates the penetration of the tannin into the leather, and by lubricating the inner portion, prevents damage by rubbing of the grain against the sides of the drum.

**Castor-oil soap.**—This is an excellent material for fat-liquor. It can be made in the tannery in the following manner: Dissolve 2 lb. of caustic soda in 1 gallon of water. Heat 2½ gallons of castor oil to 90° F., then pour the soda solution into the warm oil, and stir the mixture until it becomes thick. Cover the tub containing the soap, and let it stand over night in a warm place. The soap is ready for use the next day. It is advisable, but not absolutely necessary, to melt the soap again in a jacketed pan fitted with a stirring apparatus, by means of which a more thorough mixing of the soap is obtained.

**Potash soap.**—For any purpose for which a potash soap is required it is essential to use a pure article, but this is not always obtainable, so to be sure of having a pure product the safest course is to make it. This is easily done, as pure caustic potash can be readily obtained. A good soap can be made, even with crude appliances, according to the following formula: Put 224 lb. of red oil in a kettle and heat it to 100° F.; then run in slowly, with constant stirring, 10½ gallons of solu-

tion of caustic potash of 60° Twaddell. Allow to stand 24 hours and the soap is ready for use.

**Oiling chrome leather.**—The finishing of chrome leather cannot be called currying, as no heavy stuffing or hard grease is used, the only grease the leather receives being an emulsion of oil, soap, and degras, or some other suitable material, and a coat of oil applied to the grain before it is dried. The oils used for oiling the grain of chrome leather are neat's foot, olive, sperm, sulphonated, and paraffin. Neat's foot is often used alone as well as mixed with paraffin oil. A good mixture for chrome glazed leather is 1 part neat's foot and 3 parts paraffin oils; and for dull-finished leather equal parts. They should be warmed, mixed, and applied warm, the leather being well struck out with a slicker before it is oiled.

Another good combination is 1 part olive oil and 3 parts paraffin oil. The mixture should be applied evenly over the grain, more being put on for a dull finish than for a glazed finish. It is best not to oil the flanks. Sperm and olive oils are good for colored leather.

A pure petroleum oil, such as 34° gravity neutral, is suitable for any glazed leather. Good results are obtained by mixing it with what is known as fleshing oil, using equal parts of the two oils. Heat the oils to 200° F., mix well, and let the mixture cool before it is used.

To preserve the finish and prevent spewing, a coat of the petroleum oil heated to 100° F. should be applied to the leather after it is finished. The so-called finishing and kid oils are nothing but 34° neutral petroleum oils, although they are generally sold under fancy names at fancy prices. Fleshing oil is much cheaper than neat's foot, and produces equally good results.

The paraffin oils, when used together with pure cod oil in proper proportions, are satisfactory for sole and rough leathers. The proportions of the two oils should be 25 to 60 per cent paraffin and 40 to 75 per cent cod; a good mixture is 60 and 40, respectively. The regular 28° paraffin oil is the most suitable for rough and sole leathers.

Sulphonated castor oil is also used after glazing and before drying to prevent the leather from cracking and oxidizing in the air. In this case it is sufficient to apply a light coat of sulphonated oil (50 per cent water) to the grain before drying. Some tanners prefer to use for this purpose a mixture of equal parts of sulphonated castor oil and a light-colored mineral oil.

Specially treated oils, which have great softening properties, preventing spew and gum, and do not discolor the most delicately colored leather, are also procurable.

Low grade and impure oil should not be put on chrome leather, as such oil undergoes a process of decomposition in the leather, imparts a bad odor to it, and spews out on the surface in the form of white scum, which is removed with difficulty. The quantity of oil applied to the grain is small, and it is advisable to use only the best grade for the purpose, the increased cost being not worth considering in view of the better quality of the finish.

**Waterproof filling for sole leather.**—The following method of waterproofing and otherwise improving chrome-tanned and bark-tanned sole leather, was patented by William R. Smith and assigned to the Buffalo Leather Co., of Buffalo, N. Y.

A bituminous composition is introduced into the leather by bringing the latter into contact therewith at a temperature high enough to render the composition thin and fluid, but not high enough to injure the leather. The maximum temperature varies with the kind of tannage, vegetable-tanned leather resisting a temperature of 150° F. and chrome-tanned up to about 200° F. To ensure proper impregnation, the leather should be free from oils, glucose, etc. It is best to treat the leather in a rotary tumbling drum. The fluid mixture and the heated soles are put into the drum, which is steam-jacketed and heated, so that the temperature of the air within it is somewhat above the melting point of the mixture. The drum is preferably provided with radial inwardly projecting shelves adapted to raise and release the composition and the pieces of leather as the

machine rotates. The operation is continued until the composition has thoroughly permeated the leather. Whole sides may be treated, but the inventor prefers, for economy of the mixture, to tumble the leather with the composition after it has been cut into forms or soles of the final size. The process is ordinarily completed within one-half hour.

The bituminous composition used contains as its essential components a solid bitumen possessing a considerable degree of elasticity, combined with some other bitumen having marked penetrative powers. The variety of elastic bitumen preferred is elaterite or "mineral rubber," and the variety of penetrative bitumen is ozokerite, a "mineral wax." While the elaterite is greatly desired in such a composition, its use has been prevented by its infusible and insoluble character, also by its viscosity when brought into a state of fusion by admixture with other bitumens. This difficulty is overcome by altering the character of the elaterite so as to render it easily soluble in melted ozokerite or equivalent paraffin. When elaterite is gradually added to a melted bitumen, such as gilsonite, which is capable of withstanding a high degree of heat without decomposition, it is softened and gradually dissolved, and thus an infinitely large quantity can be melted in the presence of a small amount of gilsonite. The elaterite, fusible at high temperature without decomposition and soluble in hot paraffins and forming therewith a thin, penetrating liquid, is herein termed "modified elaterite."

An example of modified elaterite is the so-called "kapak," a bitumen well-known in the trade and produced from elaterite. The elaterite found in Utah (ozokerite also comes from that State) has all the desired qualities for this process. It is non-friable, tenacious, only moderately brittle at low temperatures, elastic at normal temperatures, resilient, and resistent to chemical alteration. When slightly warmed it becomes more flexible and more elastic so that if drawn out or bent—like rubber—it tends to return to its former shape upon release. It may, by fusion with a solid paraffin body, be brought partly into solution, but it is preferable to render it substan-

tially soluble in melted solid paraffin by previous modification. Ozokerite, having a higher melting point than ordinary solid paraffin, is found to be a superior ingredient in this special composition. The proportion of paraffin to modified elaterite naturally varies somewhat according to the specific qualities given the latter, 3 parts of ozokerite to 1 of modified elaterite being generally suitable.

The flexibility and resiliency of elaterite are found to be measurably retained by the composition, and in addition, it possesses a surface frictional resistance such as is possessed by beeswax. The value of this latter quality is clearly observed when chrome-tanned sole leather is worked through this process. Notwithstanding the durable character of chrome leather, its use for the soles of shoes has been greatly limited by its slippery nature in wet weather. When chrome leather is impregnated with the composition by this process, this undesirable quality is effectually overcome. The wearing quality of heavy leather of all kinds for use as soles and heels is greatly increased by this treatment. When finished leather filled with ordinary paraffin wax is placed in hot sunshine or near a stove there is a strong tendency for the wax to melt and exude, thus defacing the shoe or other article. On account of the viscosity and high melting point of the composition used in this process the leather is not injured by any similar rise in temperature.

Another combination, which is not patented, consists of a mixture of 50 parts paraffin wax, 25 parts of rosin, and 25 parts of carnauba wax.

**Stuffing chrome lace leather.**—After the stock has been tanned, neutralized, and washed in the usual way, it should be placed in a hydraulic press, or run through a Quirin wringer to take out the excess moisture. It should be run in a dry mill to take out all the wrinkles, and then allowed to sammie to contain approximately 40 per cent of moisture, taking great care to prevent any portions of the hide from becoming dry and eventually dark when stuffed with grease.

When the leather has been properly sammied, it should

be weighed, placed in the stuffing drum which has been previously heated to 180° F., and allowed to run for about 5 minutes so as to open up and become heated through. Then add to the drum for each 100 lb. of stock 10 lb. of oleo-stearine substitute and 3 lb. of No. 3 "setine," melted together at a temperature of 150° F. Run for about 30 minutes, or until all of the grease is well taken up. The leather is then removed from the drum and hung on hooks until the grease has set and the stock is perfectly cold. This permits the leather to absorb the grease so that no excess is left on the flesh and grain.

The stock should then be placed in clean water at not over 90° F., and should remain in this water for about 10 minutes, or until the fiber has taken sufficient water to set out easily.

It should then be taken from the water, placed on the table and struck out on the flesh with a slicker; then turned over, set out perfectly on the grain, and oiled off with No. 3 setine, giving a fairly liberal coat along the back and over the hips, and a light coat over the balance of the hide. The stock should then be hung up from head to tail until the oil has sunk in from the surface. It should then be tacked out and dried in the usual way, after which it should be sammied with water, or preferably in sawdust, staked, and finished.

Shaving the flesh lightly on the machine decidedly improves its appearance, after which the grain should be glassed by hand and then a light coat of talc put on with a brush and well rubbed in and the excess wiped off with a woolen cloth.

Each of the above products is pure white and assimilates perfectly with the moisture in the leather. They will not oxidize, nor will they react with the chromium salts.

The proportions recommended must necessarily be varied to meet requirements. If the leather is inclined to be soft, oleo-stearine substitute alone may be used to advantage, using only the No. 3 setine to oil off after setting, so as to mellow the stock along the back and over the hips.

# CHAPTER XV

## FINISHING LEATHER

In the previous chapters have been described the various processes employed for treating hides and skins. Rather than carry each kind of leather through the final finishing process

Figure 97.—Exterior view of Proctor dryer.

it has been thought best to bring them to a point where the final operations of producing a marketable product become necessary. Thus we have studied beam-house methods, tanning processes, coloring and fat-liquoring, and now we will consider the application of various seasonings and the mechanical operations necessary to produce the desired results.

*Setting-out.*—For practically all classes of leather the stock is set-out after fat-liquoring. This is done on machines or may be set by hand on a smooth-top table. In any case, the

idea is to smooth out the leather and free it from excess of liquor.

*Drying.*—The skins or hides having been set-out are next dried. This is usually done by hanging the stock in a dry loft. Skins are, as a rule, suspended by the butt, while sides are suspended by the butt and neck. The conditions of the dry loft vary greatly with the kinds of stock, but, as a rule,

Figure 98.—Skins entering at the "wet end" of Proctor dryer.

it may be said that vegetable-tanned stock should dry slowly, while chrome-tanned stock will stand a higher degree of heat in the loft. For chrome-tanned stock several forms of rapid mechanical dryers are employed, the most common being known as the Proctor dryer, shown in figures 97, 98, and 99.

In the ordinary dry loft the skins are suspended from hooks or over sticks (figure 100), and the temperature regulated by means of steam coils passing under a grating on the floor. To ensure a proper circulation of air, most dry lofts are provided with fans of the blower type, which may be used either

to blow the air into the loft, or may be placed so as to draw off the moisture-laden air. This method is best shown in figures 101, 102, 103, 104, and 105.

The drying tunnel has been found to give exceptionally good results on chrome leather. This consists of a long narrow tunnel on each side of which is an endless conveyor, both the Proctor and Sturtevant being types of such equipment. The damp stock enters the cool end and gradually approaches


Figure 99.—Skins leaving the "dry end" of Proctor dryer.

the hot end of the dryer from which it is removed when in the proper condition.

*Dampening.*—After the leather has been dried out, in order to set the fiber it must again be dampened back or sammied before carrying out the finishing processes. Two methods of dampening leather are employed, the first consisting of dipping the stock in warm water, and then packing down in pits over night; and the second in placing the leather in piles with damp sawdust between each skin, and then covering the pile completely with more damp sawdust. By either of these methods the stock becomes uniformly damp without containing an excess of moisture in any part.

*Staking.*—When the leather is in a properly sammied condition it is ready for stretching or softening, which is done in several ways. The most common method of stretching is accomplished by working the skin or sides on a staking machine, illustrations of which are shown in figures·106, 107, and 108. The leather is placed on the bed of the machine, and is then held in position while the jaws close in, and on retreating impart a pulling and breaking effect. In place of machine staking, an older method consists in working the skins over a blunt knife, pressure being applied by placing the knee in the fold of the leather and drawing downward. This is known as knee-staking, and is illustrated in the chapter on Alum Tanning. Leather is also softened and stretched by means of the moon knife, which gets its name from its peculiar shape. This method of staking is spoken of as "perching."

Figure 100.—Interior of a typical dry-room in a goatskin tannery. The room is heated by steam pipes on the floor and ventilated by means of fans.

*Buffing.*—When it is desirable to produce a velvety appearance on the flesh side of the leather, the dry skins are passed

over a carborundum or emery wheel, as shown in figure 109. This is sometimes done while the stock is still wet, in which case a carborundum stone is used, known as a "wet wheel."

*Tacking.*—To conserve as much measurement as possible and produce a smooth piece of leather the stock is usually tacked. This is done by placing the sammied and staked leather on a frame and tacking around the edge. In carrying out the operation the skin is placed flat on the board and

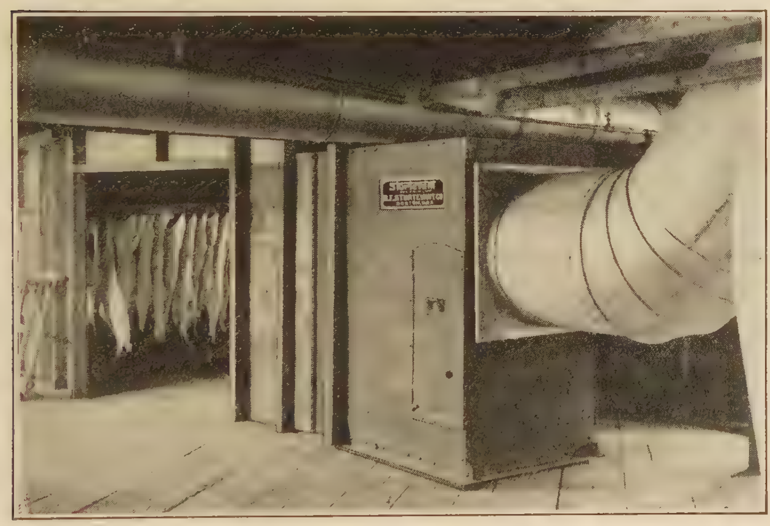

**Figure 101.—Side view of Sturtevant dryer showing supply pipe, heater and open tube.**

several tacks are placed in the butt. The neck is then pulled tight and tacked in position. Tacks are then driven along the sides, two men usually working on one skin on opposite sides. The care taken in this operation has a great influence on the finished product. When tacked, the stock is allowed to dry.

*Stripping.*—When thoroughly dry on the boards the tacks are withdrawn, or what is known in the trade as "stripped."

*Seasoning.*—On removal of the skins or sides from the boards they are ready for the application of the seasoning solutions. These vary, and may be applied by hand, with a

brush, or on the seasoning machine. Some finishes require only one application, while others may require a number.

*Rolling.*—For semi-bright leather the stock is usually worked on a rolling-jack. This machine consists of an arm to which a steel roll is attached. This roll, in playing on the bed of the machine, imparts a smooth surface to the leather with

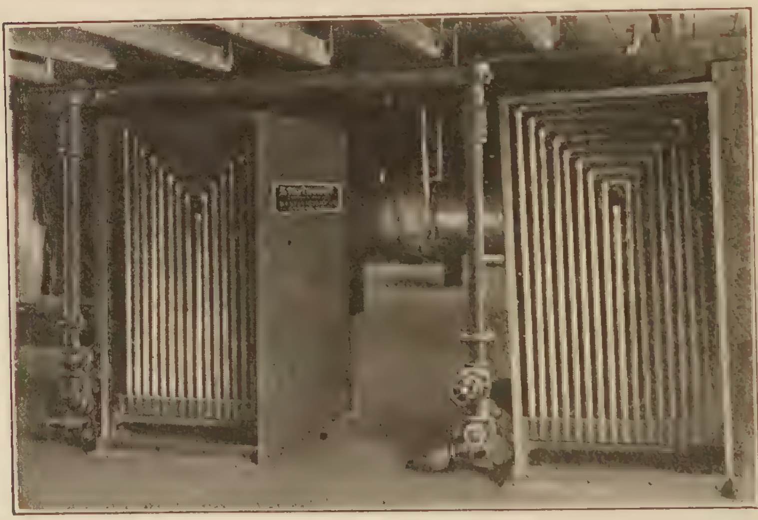

Figure 102.—Rear end of heaters, Sturtevant dryer, showing steam and drip connections.

which it comes in contact. Patterns are also sometimes embossed on the roller.

*Glazing.*—For leather which is to be finished with a high gloss the glazing-jack is used. This machine somewhat resembles the rolling-jack, except that the arm is provided with a glass cylinder which remains stationary, and in passing over the bed causes a certain amount of friction. The heat produced thus imparts a bright polish to the leather. Two types of such machines are shown in figures 110 and 111, while a "line" in operation is shown in figure 112.

*Ironing.*—When a dull finish is desired, the stock, in the case of chrome-tanned leather, is oiled and then ironed with

a hot flat iron. The same result may also be obtained on a smooth plate machine as described under embossing.

*Embossing.*—When it is desired to impart an artificial grain to a leather it is placed between the plates of an embossing machine. These machines are capable of great pressure, and may be used for smooth-plating or embossing as desired. Such machines are shown in a previous chapter.

**Figure 103.—Sturtevant leather dryer, double tube, showing drying trucks.**

*Boarding.*—For some finishes, and when a soft leather is required, it is customary to work the rolled, glazed, or embossed stock on the table with an arm board. By the folding action thus produced the grain is raised and various effects are obtained.

*Measuring.*—As all light leather is sold by the square foot, it becomes necessary to take measurements. Several machines are on the market for this purpose, but they all work on the same principle. Figure 113 illustrates a Turner measuring machine.

*Sorting.*—The skins are sorted and made ready for market as shown in figure 114.

Having briefly outlined the steps employed in finishing light

leather we will now notice their application to the various kinds and grades of leather.

**Finishing chrome-tanned sheepskins.**—After chrome-tanned sheepskins have been dyed and fat-liquored, they are struck out and the grain is oiled lightly with a mixture of 1 part of neat's foot oil and 3 parts of paraffin oil for glazed finish, and equal parts of neat's foot and paraffin oils for dull

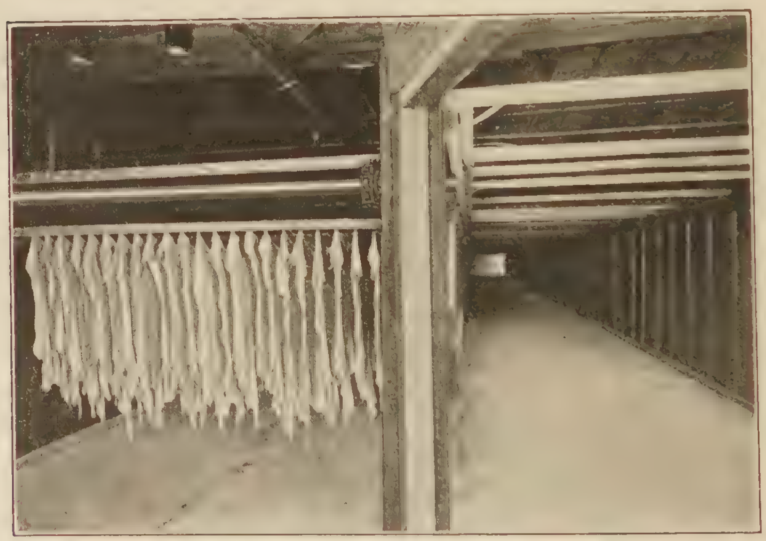

**Figure 104.—End of two tubes of Sturtevant dryer, showing skins hanging from chain belt-conveyor.**

finish. Care must be taken not to give the skins too much fat-liquor as this makes them too soft and spongy. After the grain has been oiled the skins are hung up to dry. The best results are obtained from rather slow drying in a room with a temperature of about 80° F., and having a good circulation of air.

When dry, the skins are dampened and staked. A satisfactory way to dampen them is to put about a dozen skins into a tub two-thirds full of water, leaving them two or three minutes therein, then placing them in a well-covered pile on the floor or in a box. When they have become pliable they are staked and re-staked, and then tacked on boards

to dry. When thoroughly dry, they are taken off the boards, trimmed, and prepared for the work of finishing.

*Black glazed finish.*—Where the grain of the leather is greasy, it is advisable to apply a dilute solution of acid to clear it. Either lactic or formic acid may be used. The acid, diluted with water, is rubbed into the grain and the leather is dried. Then the grain should be rubbed with a

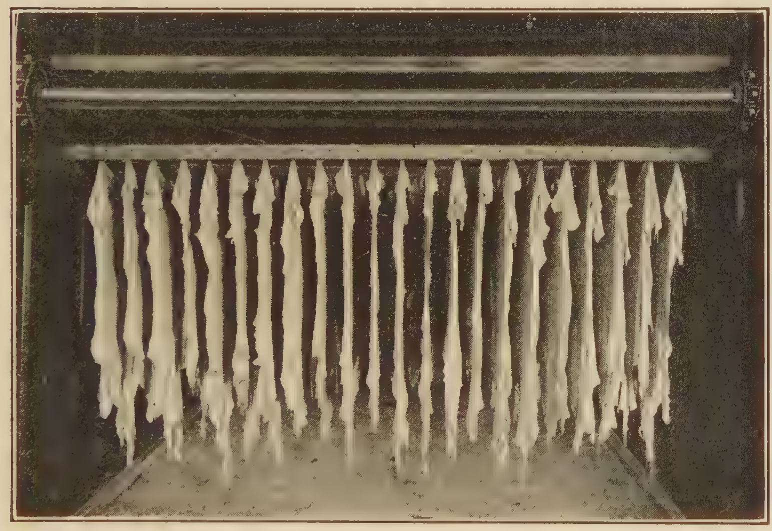

**Figure 105.—Looking into the end of Sturtevant leather dryer, showing skins on conveyor.**

soft cloth and given the first coat of seasoning. The acid assists in getting a clear, bright finish.

An excellent seasoning for black-glazed finish is made of the following ingredients: ivory soap, 1 lb.; glue, 1 lb.; logwood crystals, 3 oz.; nigrosine, 4 oz.; potassium dichromate, $\frac{1}{2}$ oz.; fresh beef blood, 2 quarts.

Dissolve the soap and glue each in 8 gallons of boiling water; dissolve the logwood and nigrosine in 2 gallons of hot water, and add the dichromate; when cold, add the blood. Take 1 quart of the glue solution and 1 quart of soap solution, and mix into the logwood and blood solution; stir well and strain. Rub a light coat of this seasoning into the grain

of the leather. Dry in a warm room and glaze. Apply a second coat of seasoning, dry, and glaze again. Finally, after the finish has aged a little, oil it very lightly with warm finishing oil or with a mixture of equal parts of neat's foot and paraffin oils.

The following formula also produces an excellent seasoning for glazed finish: whole flaxseed, 2 oz.; logwood crystals,

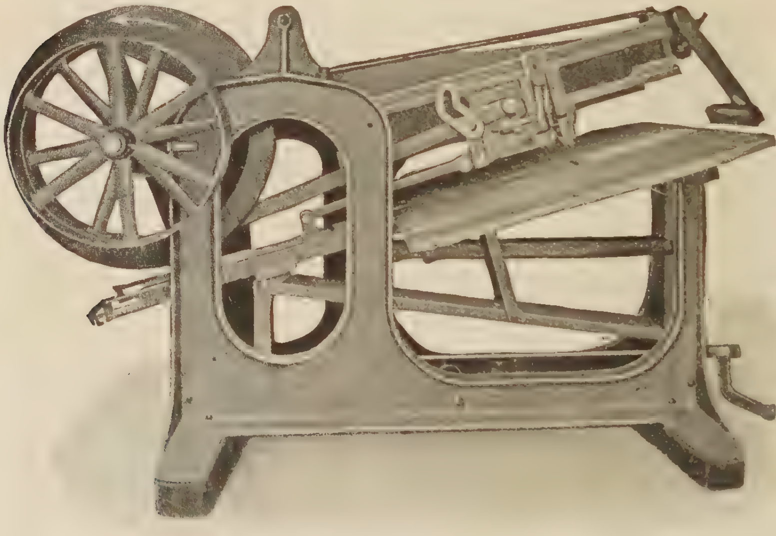

Figure 106.—Standard staking machine.

2 oz.; nigrosine, 2 oz.; potassium dichromate, $\frac{1}{2}$ oz.; blood, 1 quart; glycerine, $\frac{1}{2}$ pint; and carbolic acid crystals, 1 oz. Boil the flaxseed 30 minutes in 1 gallon of water; then strain the solution and add the logwood, nigrosine, and dichromate and boil again; then cool the solution to 90° F., and stir in the blood, glycerine, and carbolic acid. There should be 2 gallons of seasoning. If there is less, add enough cold water to make the quantity specified. Apply the dressing to the skins, dry, and glaze in the usual manner.

Another formula for glazed finish is: blood albumen, 1 lb.; black nigrosine, 5 oz.; logwood crystals, 1 oz.; and denatured alcohol, $\frac{1}{4}$ pint.

Dissolve the blood albumen by standing over night in 1 quart of water. Boil the nigrosine and logwood in 3 gallons of water. When the solution is cold, add the albumen and alcohol. Give the skins two coats of this seasoning, and glaze them twice.

When the grain of the leather is greasy, it is best to rub

**Figure 107.—Staking, or softening and stretching the damp stock.**

in a solution of alcohol and black nigrosine. Dissolve 1 oz. of nigrosine in 1 gallon of water and add a little alcohol. Rub this into the grain of the skins, and apply the seasoning when dry. The black is deepened by this treatment and the grain is cleared.

A solution of oil-soluble nigrosine in benzine is beneficial in touching up spots which are not a good black.

A kid finish on black sheepskins can be secured by the use of the following seasoning: logwood liquor, 6 quarts; beef blood, 2 quarts; orchil, $\frac{1}{2}$ pint; water, 1 quart; ammonia, $\frac{1}{4}$ pint; and milk, $\frac{1}{2}$ pint.

There are excellent seasonings on the market, so the tanner

can buy them and dispense with the labor of making his own finishes. This is done by many, who find it convenient and advantageous.

*Seasoning for dull finish.*—The following is a good prescription: ivory soap, 1 lb.; flaxseed, ½ lb.; beeswax, 4 oz.; black nigrosine, 4 oz.; gelatine, 4 oz.; aloes, 2 oz.; and denatured alcohol, ½ pint. Put the soap, flaxseed, and beeswax into 2

**Figure 108.—Perching goatskins, sometimes termed re-staking.**

gallons of water and boil 30 minutes, then add the nigrosine. Dissolve the gelatine in 1 quart of water and add to the solution. Then dissolve the aloes in the alcohol, add to the other solution, and strain the mixture. Apply a coat of this dressing to the grain of the leather, rubbing it in well. When it is dry, iron the leather, and then give it a second dressing, but do not iron it again. As a finishing touch, oil the grain with paraffin oil.

*Seasoning for colored sheepskins.*—1. A clear, bright finish is obtained on colored sheepskins by using a seasoning made of 4 gallons of egg-albumen solution, 1 oz. of potassium

dichromate, 2 quarts of acetic acid, and 20 gallons of water. The ingredients should be mixed thoroughly. The seasoning should be applied sparingly so that the grain and wool pits will show when the leather is glazed.

A glazed finish is obtained on russet and colored leather by using the following dressing: Dissolve 4 oz. of blood albu-

**Figure 109.—Buffing room in a goatskin tannery.**

men by standing over night in 1 gallon of water; cook 4 oz. of granulated gelatin in 1 gallon of water and let it cool; mix $\frac{1}{2}$ pint of white shellac varnish with $\frac{1}{2}$ pint of ammonia; mix the three solutions thoroughly, add enough water to make three gallons, apply to the skins with a sponge, and glaze when dry. For colored skins, use a little less ammonia and make the finish a week before it is to be used, so that the ammonia will evaporate. For a plain natural finish, give the leather two coats of finish and roll it while it is wet, hang it up to dry, and then give it another coat of dressing. Boil 1 lb. of flaxseed for some time with $3\frac{1}{2}$ gallons of water.

Strain the solution before using it, and beat it up the same

as the white of an egg. To a pail of water add $1\frac{1}{2}$ pints of milk, the whites of two eggs well beaten, and $\frac{1}{2}$ pint of flaxseed liquor also well beaten up. This finish should be put on evenly and without streaks by means of a soft sponge or a sheepskin pad. When it has been put on, the skins are hung up to dry and then rolled.

If embossed leather is required, the skins should be sea-

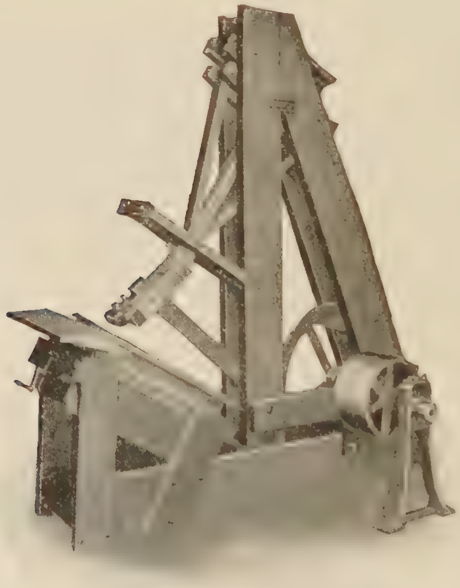

**Figure 110.—Bower glazing machine.**

soned and then embossed by an embossing machine. Imitations of seal, monkey, alligator, and other skins are made in this way. Beautiful effects are produced when the leather has been properly tanned and colored.

*Finish for embossed sheepskins.*—These skins, tanned by a vegetable process, and to be grained or embossed, can be seasoned with the following finish: 2 oz. of casein; 2 oz. of orange shellac; $\frac{1}{2}$ oz. ammonia; and 1 gallon of water. Let stand over night, or until solution is complete. Add 1 gallon of water and $\frac{1}{2}$ oz. of glycerine, mixing all together. Apply

with a sponge, and dry. The skins are then ready for glassing on the machine. After glassing, they may be grained by arm board and embossed, which is the final operation.

*Finish for black embossed sheepskins.*—A lasting finish is obtained by using this dressing on skins that are to be printed, grained, pebbled, or embossed. Put 8 oz. of extract of logwood, 1 oz. of potassium dichromate and 2 oz. of prussiate of potash in 2 gallons of water, and boil until dissolved; cool,

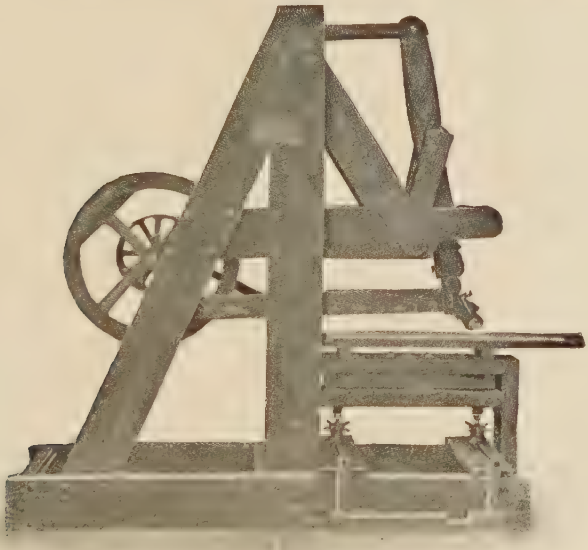

**Figure 111.—Flat bed glazing machine.**

and strain. To each gallon of the solution add either 2 quarts of beef blood or blood albumen. Give the skins an even coat of this dressing and let them dry. When the leather is ready to be printed or embossed, dampen the grain evenly so that it will take the impression without the grain being cut. Then print, grain, emboss or pebble according to the grain desired. Skins may be embossed in a dry state on a modern embossing machine, although a certain amount of heat is used to make the impression easier and more permanent.

On some kinds of embossed leather it is desirable to have

the crevices of the grain a lighter shade than the upper surface, which gives the leather a shaded appearance. To obtain this effect, the skins should be embossed first, and then colored by hand on the table. This not only produces the desired appearance as regards color, but also leaves the flesh clean and uncolored. East India skins are nicely colored this way.

**Figure 112.—A line of glazing-jacks for producing a bright finish on glazed kid.**

When skins are colored first and then dried and embossed, the plate of the machine should be large enough to cover an entire skin, so that there will be no plate marks on either the flesh or grain side. To keep the flesh smooth and free from plate marks a thick piece of cowhide split should be spread over the bottom bed of the machine. The skins to be embossed are placed grain side up on this split. The plate then comes down on the grain and embosses it, while the flesh side remains smooth. Before embossing, the grain must be seasoned and glazed with considerable pressure, so that it will be flattened out and smooth. Two or three glazings are gener-

ally needed to get the right finish. When a sort of crushed or wrinkled grain is desired, strong tan liquor is used, which contracts the grain. Embossing is generally more satisfactory, as it produces a more uniform result.

Very thin fancy leather is obtained by boarding or embossing plump skins and then splitting them. The grain should

**Figure 113.—Segment measuring machine.**

be diced by rolling with a diced roller and then hand-boarded. The flesh splits are finished into ooze leather.

*De-greasing sheepskins.*—As already stated, much of the natural grease in sheepskins can be removed by pressing in a hydraulic press previous to tanning, or while the goods are in the limed or the pickled condition, preferably the latter. Pressing before tanning is always advisable, yet this method is not always as effectual as might be desired, especially when colored leather is to be produced. Treatment with naphtha in liquid or gaseous form is therefore often resorted to. This method of de-greasing usually removes every particle of grease and oil from the leather. It is used after the tanned skins

have been dried and before they are finished. The work of de-greasing with naphtha should be done in a building apart from the main factory, and no fire or open light should be allowed near the naphtha vats.

The skins are immersed in the naphtha in a tank or closed vessel or drum, which either revolves or in which they can

**Figure 114.—Sorting finished skins.**

be stirred or otherwise agitated to ensure rapid and thorough permeation of the naphtha. By processing the greasy leather in this manner the liquid becomes so thoroughly saturated with the oily matter extracted that it will take up no more. If one bath is not sufficient to extract all of the grease, the skins are removed to a fresh bath. They may be repeatedly subjected to a fresh supply of naphtha, until the liquid in which they are last placed remains pure and shows no trace of oil or grease. The action of the naphtha is harmless, and no strength of the leather is lost by this treatment. The leather can be de-greased by soaking it in the fluid for several hours and then pressing out the naphtha with a slicker. On a

small scale, the work can be done by throwing the skins in loosely and separately, and stirring them about for an hour or two. Light skins show a difference after they have been in the liquid a half-hour. When they seem sufficiently degreased they should be taken from the naphtha, pressed out with a slicker, and then hung up until the naphtha is entirely evaporated.

**Finish for India-tanned leather.**—India-tanned skins are finished in various ways. Large quantities are finished in smooth glaze and dull; some are grained with a roller or embossed and then boarded up by hand; and others are glazed and grained. For some purposes, such as bags, belts, etc., they are hand-grained three ways, which gives a round and half-round grain. To get a diced grain, the skins are rolled with a straight grain roller and then grained crosswise; after this they are boarded up, which softens them and produces a uniform grain similar to the box grain. Some skins are pebbled and then boarded. The finish depends upon the purpose for which the leather is to be used.

*Black glazed finish.*—The skins, after they have been staked, are in condition to be finished. Seasoning for glazed finish is applied and rubbed into the grain. The skins are then dried in a warm room and glazed. A second coat of seasoning is then applied, dried and glazed. Sometimes it is advisable to stake the skins again after the first staking and before the second application of seasoning.

*Smooth dull finish.*—A fine dull finish and soft, full skins are obtained by giving them after staking a coat of dull dressing, drying and ironing, after which they are staked lightly.

*Finish for colored skins.*—An egg-albumen solution produces a fine glazed finish. Apply with a sponge and glaze when it is dry. Egg-albumen is used for light shades, and blood albumen for dark shades.

*Re-tanning with chrome liquor.*—Soft, durable leather is made by re-tanning India-tanned skins with one-bath chrome liquor. The skins are first sorted and all superfluous parts trimmed off; they are then soaked and shaved. After shav-

ing, they are washed thoroughly, drained a few hours, and then re-tanned with chrome liquor. Any good one-bath liquor may be used. A stain can be added to the liquor, and re-tanning and staining performed in one operation. When the re-tanning is completed the leather is washed, pressed or struck out, dyed, dried, and finished.

*Morocco finish.*—There are three different ways of giving the leather a grain or the "morocco finish," as it is called. The best way is by graining it up naturally without giving it any false grain. This is done by a cork board when the skin is wet. The grain of the skin is turned to the grain and pushed backward and forward in eight ways, turning the skin each time. This method throws up a beautiful grain and makes a regular morocco figure. Heavy skins throw up a large grain, while the grain of light skins is fine and small. To hold this grain the skins are hung in a hot room to dry. This, of course, makes them hard and stiff, and it is necessary to go through the same work again, only with the skin dry instead of wet. This method keeps the former grain and makes the leather soft and pliable.

Another good way, where prices enter into the question, is to take the skins from the dry room, wet them and put them under a jig roll. This is a small steel roll about 6 inches long, cut with indentations, so that the roll under great pressure on wet leather gives a pebbled or morocco figure. This also must be dried in, then wet down, and hand-grained just as the natural grain skin. This gives a beautiful regular morocco grain which will not pull out or flatten; and it is done without deterioration to the leather itself.

The least desirable way, though much used, and really the best known among bookbinders, is embossing. The objectionable feature to this process is that, to keep the figure in, it is necessary to use heat. This injures the fibers and the grain, leaving the leather with an unnatural grain. No good work should be embossed. The process is most suitable for sheepskins or other skins when no other method will do, or else for any poor stock which cannot be finished in any other

way. The grain can be made bright by glazing at any time during these processes.

The leather is next split. The grains are used for bookbinding and other purposes, while the splits are made into ooze stock, which is used for pillows, linings, covering handles of golf sticks, etc.

*Crushed Levant grain.*—This is obtained by embossing, then seasoning and glazing to flatten out the grain. Two or three glazings are needed to get the desired finish. The colors are generally blue, red, green, brown, tan, and wine. To get the best results in coloring it is advisable to emboss the skins and color them on the table, this giving the crevices of the grain a lighter hue than the upper surface, besides leaving the flesh clean and white.

Plump leather always takes a good grain in boarding. For boarded grains it is best to roll them with a diced or straight grain roller. Should the latter be used, the skin should be rolled diagonally to form a small diamond, and afterwards hand boarded. The leather, if sufficiently plump, can be split so that the grain will be of the desired weight. The grains finished as described are used for collar and cuff-boxes, belts, hand-bags, pocketbooks, music rolls, etc.

*Ooze or suede leather.*—India-tanned skins having defective grain can be made into ooze or flesh-finished leather more profitably than into other grades. Softness and good color are the essential qualities, as well as a short, smooth nap.

The following describes the methods used in finishing India-tanned ooze leather: The skins are sorted, and those having good grain are colored and finished on the grain; while those having poor grain are thrown aside for ooze finish. The imperfect skins are thoroughly washed and cleansed of dirt and surplus tanning material, struck out to rid them of surplus water and snuffed on the wet wheel.

The next process is re-tanning with sumac, which not only re-tans the skins, but also prepares them for coloring. The sumac is applied in a warm solution in a drum, and the skins are then colored. Coloring is usually done in a drum, the

tumbling and pounding being necessary to carry the color into the leather. After the skins are colored they are fat-liquored, dried, staked, and rolled.

**Finishing skivers.**—The work under this heading covers a large assortment of grains, rolled or embossed, as well as glazed. After the skins have been fluffed lightly, if required, they should be given a coat of Irish moss solution on the flesh, this having the effect of making them feel firm and stout. A practical way of making up the moss mucilage is by boiling gently equal parts by volume of Irish moss and water for about two hours, after which the solution is carefully strained. When it is cold, it is ready for use.

A coat of moss is applied to the flesh side, and the skivers are slowly dried out. The flaming, or filling of the grain, follows, the solution for this purpose being made from 10 oz. of liquid blood albumen, 1 oz. of milk, and 1 quart of water. Apply liberally with a brush, as this class of skivers requires considerable nourishing. A suitable seasoning is then applied with a pad.

At this stage the skivers are laid under damp blankets for not less than 12 hours, when they are ready for the machine work. If the goods are for long grains they should be first well rolled with a dull roller—either a No. 4 or 5—from belly to belly, two or three times if necessary, taking care to bring up a good color. Next break the skins down on the flesh side, with a hand board covered with rubber, air off and then glaze carefully. This has the effect of giving them a good level face and also flattens the roller work.

The skivers are now embossed on the plate machine with whatever grain is desired. If, however, the goods are for straight grains, they should be first rolled with a No. 7 size roller, lightly boarded on the flesh, and then cut through with a No. 4 to separate the "oat" which has been made by the No. 7 roller, and finally lightly finished off on the glazing machine. Goods for cross-grains should be rolled on the cross with a No. 5, boarded on the flesh, well glazed, and then boarded again on the grain. For plain glazed skivers great

care should be taken in glazing, no matter what class of machine they are to be glazed on; it should be in perfect condition and should have a good level stroke. Too much pressure must not be used, otherwise the goods will be very brittle, and it will be difficult to finish without tearing. Such goods should be well glazed, aired off with a little heat if possible, and then lightly drummed.

For glacé embossed skiver grains, only the stoutest skivers should be selected; those showing ribby marks should be rejected. Skins showing rough flesh should be cleaned up by a light fluffing on the wheel, care being taken that the carborundum or emery wheel is not rough enough to leave marks. Then give the skivers a good coat of Irish moss solution of about the same strength as that for flat finishing. Next fill in with a solution composed of 8 oz. of liquid blood albumen, 1 oz. of milk, and 1 quart of water, adding a little color solution if desired.

The goods are now dried slowly; if dried too rapidly they will be harsh and liable to crack. When dry, they can be broken down on the flesh side with the rubber-faced hand board, and placed between damp sacks for about an hour, when they are ready for embossing to the grain required. In the embossing, the impression of the print is, of course, left on the flesh side; or, to be exact, the impression on the grain side is, of course, raised up on the flesh side, and vice versa. By running the fluffing wheel lightly over the flesh side it only touches the skin where the raised parts are; consequently this part of the skin is left a little thinner, and the glazing tool cannot get to the bottom of these parts, being held by the raised parts of the print. The friction caused by glazing darkens the goods or brings out the color, the result being a lighter shade between the scales and what appears a much more natural grain. The skivers are now ready for seasoning and the final work of finishing. There are great possibilities in this class of work, as frequently there is a fresh design on the market, while there is a constant and increasing demand for both glazed and plain embossed skivers. The

above notes on the finishing of skivers is taken from *The Leather World.*

**Seasoning for chrome calfskins.**—After the skins have been trimmed, apply a coat of finishing seasoning, dry, and finish. Make the seasoning of 1½ lb. of ivory soap, 3 oz. of French gelatine, and 3 oz. of blood albumen.

Shave the soap into 6 quarts of water and boil until dissolved. Dissolve the gelatine in 1 quart of hot water. When both solutions have cooled, mix, and stir them together. Soak the blood albumen over night in 2 quarts of water at 90° F. In the morning stir the soap into it. Strain a quart of the finish into 6 quarts of warm water. Apply a coat of the dressing to the leather, allow it to dry, then stake lightly and give a second application, and dry again. When the leather is still somewhat moist, roll it; then dry and jack it lightly, using a piece of hard felt instead of the glass. The pressure must be light, or the leather will show shaded spots.

*Bright finish, smooth or boarded.*—This is obtained in the following manner: Apply to the staked and trimmed leather a coat of seasoning for glazed finish, and when it is dry, glaze under moderate pressure. Then put on a coat of finishing oil and iron the leather. A second coat of glaze seasoning is then applied, and after it is dry, the leather is glazed again. This gives a popular and smooth finish. If a box grain is desired, board the skins after the second glazing.

*Glazed finish.*—When the leather has a clean, dry grain it is not difficult to get a good bright finish, and only a little seasoning or finishing solution is required. Such a finish cannot be secured where the grain is greasy, when too much seasoning is applied, or when the pressure of the glazing machine is too high.

A small quantity of ammonia or alcohol may be added to the seasoning to overcome oily grain, but either must be used sparingly or it will give a dry feel to the leather, and the finish will fly off during glazing. Blood seasoning is satisfactory for ordinary glazed finish. Sponging the grain with a dilute solution of formic or lactic acid cuts surface grease,

and when the grain has dried, the leather is in condition to be seasoned and finished.

Give the grain an application of the seasoning, rubbing it in well. Hang the leather up to dry, and then glaze it. Next give a second coat of seasoning, dry, and stake the skins; then glaze them a second time.

*Seasoning for black glazed finish.*—Whole flaxseed, 2 oz.; logwood crystals, 2 oz.; nigrosine, 2 oz.; potassium dichromate, ½ oz.; vinette, ½ pint; beef blood, 1 quart; glycerine, ½ pint; and crystal carbolic acid, 1 ounce.

Boil the flaxseed for a half-hour in a gallon of water, and then strain. Add the logwood, nigrosine, and dichromate. When the mixture has cooled to 90° F., add vinette, blood, glycerine and carbolic acid. Stir the mixture thoroughly, and if there is less than 2 gallons, add enough cold water to make it up to that amount.

*Boarded or box finish.*—The leather for boarded grain should be glazed and then grain-pressed. To obtain a sharp and regular grain it is best to press the leather before boarding or graining it. A powerful press and sharp-cut rolls are required. The skins are boarded first from head to tail, then from side to side. The grain is then oiled the same as for smooth finish.

*Smooth dull finish.*—Take the skins from the tacking frames and trim them. Apply a coat of dull dressing to the grain and let it dry; then give another coat and dry again. Finally, iron the leather with a hot iron, then stake it. Finished in this way the leather has a fine break and feel, and is soft and full.

Where the grain is bad, a light snuffing is required to improve its appearance. Some finishers simply apply a coat of the dressing and allow it to dry. A coat of finishing oil is then applied and the leather is ironed.

*Seasoning for black dull finish.* The same finish may be applied here as given under sheepskins.

*Gun-metal finish.*—To get this finish, after trimming, the

skins are glazed and staked. Next apply a coat of gum tragacanth, 1 oz.; yellow dyestuff, ½ oz.; and seasoning for glazed finish, 1 gallon; after which dry and iron the leather, then oil the grain with hot oil.

Soak the gum tragacanth for 24 hours in 2 quarts of water; then stir it until it is dissolved. Dissolve the yellow dye in 1 quart of water. Take 1 gallon of the seasoning for glazed finish and stir in 1 quart of the gum solution. Then add the solution of yellow dye, a little at a time, stirring thoroughly, until the color of the mixture has changed from black to greenish-black. Too much yellow dye must be avoided, otherwise the finish will be too green. For oiling off, after finishing, use a mixture of equal parts of paraffin and neat's foot, or any other good finishing oil.

**Finishing chrome goat leather.**—The skins having been colored and fat-liquored, the next operation is setting out the grain of the leather by hand or on a machine, and applying a solution of glycerine in water—equal parts of each. The leather is then placed grain-to-grain over a horse and left for an hour or two. It is then set out again, somewhat harder than before, and given an application of oil on the grain. The leather should be thoroughly set out, all wrinkles and marks of the tool removed, and the grain laid down flat and smooth. Any one of the following oils may then be used: Neat's foot, olive, sperm, or any other leather oil; mixtures of neat's foot and olive, or neat's foot and paraffin oils are good also. For instance, equal parts of neat's foot and paraffin oils make a good oil for either dull or glazed finish. It is good practice to apply the oil warm. The skins are next hung up to dry. Colored leather should be dried in a darkened room, while the drying of the black leather is effected most satisfactorily in a warm room provided with fans to keep the air in circulation.

The dry leather should be kept in a clean, dry room until it is desired to finish it; it is then sammied and staked. Staking and drying should be continued until the skins are worked out dry and soft. It is well to stake the skins both

ways on the machine. The necks and shanks are often staked by hand.

To remove roughness from the flesh, the leather may be run on an emery wheel or on a buffing machine. It is then seasoned and finished.

*Clearing the grain from grease.*—Dissolve 1 oz. of black nigrosine in 1 gallon of boiling water, and when the solution is cold, add a small quantity of wood alcohol. Apply this to the grain of the leather, rubbing it in well, then apply the seasoning for glazed finish.

*Blacking defective spots.*—Oil-soluble black aniline, dissolved in benzine, and applied with a sponge to spots which are not well blacked, dyes them at once and improves the color of the leather.

*Black glaze finish.*—A brilliant black glazed finish can be obtained by using one of the seasonings prepared in accordance with the formulas given under sheepskins. The seasoning or finishing solution should be rubbed well into the grain, a light and uniform coat being applied. Two applications of seasoning are always required to get a good finish, and frequently it is advisable to apply a third coat. After the seasoning has been applied, the skins are dried and glazed; then the second coat is put on, the skins dried again and glazed, the operation sometimes being repeated four or five times.

The finishing of glazed leather requires skill and care. The luster must be clear and bright and the grain well worked down. After glazing is completed, the leather receives a light application of finishing oil; it is then sorted into grades and tied up in bundles.

*Seasoning for colored leather.*—The same methods as given under sheepskin and calfskin apply equally well to this class of stock.

*Dull finish.*—When dull-finished leather is required, the skins are staked and trimmed, then given a coat of finish, dried, given another application of finish, dried again, and ironed with a hot iron. Heavy skins should be staked lightly

after ironing, which makes them softer and fuller than when this is not done.

**Finish for kangaroo leather.**—The glazed and dull finishes may be obtained by following the same procedure as given under goatskins.

If colored kangaroo is desired, the instructions given for calfskins should be followed.

**Finishing chrome side leather.**—After having been fat-liquored, the leather should be placed over horses to press and drain until the next day, and then thoroughly set out and oiled on the grain side. For glazed leather, use 1 part neat's foot oil and 3 parts paraffin oil, or equal parts of olive and paraffin oils, or treated cod oil, giving the grain a light application, and then hanging the leather up to dry.

Dull-finished leather may be oiled with treated neat's foot or cod oil, with dull morocco dressing oil, or with a mixture of neat's foot and paraffin oils. The oil should be applied evenly over each piece of leather, and it is best to warm it before using it. No oil should be put onto the flanks. After having been oiled, the leather should be hung up to dry in a room having a temperature of about 80° F., and there should be a good circulation of air so that it will not dry too rapidly or have a parched appearance. When dry, it is sammied and staked, and after having been staked, it is tacked out smoothly and allowed to dry. It is then trimmed and seasoned for finishing.

*Dull finish.*—A coat of dull dressing is applied to the grain of the leather, and another coat is given when it is dry. The leather is next dried and ironed with a hot iron, then staked lightly. When well tanned and fat-liquored, the leather, finished in this manner, is soft and full, and has a fine, tough grain.

*Glazed finish.*—The leather is trimmed and staked, and given a coat of finish and dried. The next operation is glazing. Then the leather is given another coat of finish, dried and staked, and glazed again. If the finish is satisfactory, a light coat of finishing oil, or a mixture of neat's foot and

paraffin oil, is applied to preserve the finish. The leather not infrequently requires a third coat of finish and a third glazing to make it satisfactory.

*Boarded finish.*—The leather is treated as for smooth glazed finish, and after the second glazing it is boarded from head to tail, then across from side to side, and oiled lightly.

Dull English grain leather is given a coat of seasoning, dried, rolled on a heavy jack with heavy pressure, then grained and oiled heavily with a mixture of neat's foot and paraffin oils. To obtain a sharp and regular box grain, the leather is pressed with a powerful press and sharp-cut rolls before it is boarded. Boarding and oiling are the finishing touches.

*Gun-metal finish.*—This finish is secured by giving the leather a coat of bright seasoning, drying, glazing, and staking. A coat of the following finish is next applied, and when it is dry, the grain is ironed and oiled off with hot oil: gum tragacanth, 1 oz.; yellow dye, 2 oz.; and seasoning for glazed finish, 1 gallon.

*Storm-grain leather.*—For chrome-tanned oil-grain or storm-grain leather the following formula makes a good finish: gelatine, ½ lb.; nigrosine, 2 oz.; olive oil, 1 pint; and ammonia, ½ pint.

Dissolve the gelatine in 2 gallons of water; add the nigrosine, and heat until gelatine and nigrosine are dissolved. Cool the mixture, and just before it begins to thicken, add the oil and ammonia, and stir thoroughly. After the leather has been seasoned and grained, oil the grain with a mixture of neat's foot and finishing oils, applied hot. Another finish suitable for heavy grain leather is made of ½ lb. of green-olive soap, 1 quart of moellon degras, 4 oz. of Irish moss, 2 oz. of logwood crystals, and 2 oz. of nigrosine.

Boil all together in 1 gallon of water for 20 minutes; cool, strain, and add water to make 2 gallons of finish. Apply this dressing liberally, and when the leather is half dry, roll it on a heavy jack, applying heavy pressure. Then grain the leather and oil off with hot oil. The leather should be rolled

while it is damp as this treatment produces a smoother grain and a more uniform break when graining.

*Finish for colored leather.*—The same procedure should be followed as given under sheepskins and calfskins.

*Heavy chrome grain leather.*—Heavy chrome leather made from the grains of split hides and from heavy calfskins is used in the manufacture of boots and shoes for sportsmen, etc. This leather is soft and waterproof, due to the chrome tannage and oils used in finishing it. The colors are black, tan, and chocolate. The leather is very durable and is well suited to such purposes. Hides to be made into this leather are split out of the limes, and the grains are then bated, pickled, and tanned in a one-bath chrome process.

Fat-liquoring is done in the usual manner after the leather has been washed, neutralized, and shaved. A good fat-liquor for 100 lb. of leather consists of 2 lb. of neat's foot oil, 2 lb. of soap and 1½ lb. of degras, thoroughly emulsified. The leather is drummed with this liquor for 40 minutes, and is then blacked by hand with logwood and striker, or with a direct chrome black. When a direct black is used, it is advisable to add a small quantity of gambier to the fat-liquor, or drum the leather in the gambier liquor before grain blacking. Where it is desired to color both flesh and grain, the leather is drummed in the dye in the usual manner, but where the grain only is to be blacked, dyeing is done by hand or on a machine. After having been dyed, the leather is washed, set out, hung up, and partly dried. A heavy coat of oil is next applied to the grain to make it soft and waterproof. A thick fat-liquor emulsion may be used for this purpose, also sulphonated oil in concentrated form. The grains are horsed-up, grain-to-grain, for 24 hours, and then hung on hooks by the hind shanks to dry. Little staking is necessary, particularly if the leather is staked while it is drying.

If a boarded finish is desired, the leather is grained in two or three directions, and a finish consisting of soap, oil, beeswax, and water—or a dull, oily dressing—is applied to the grain which is later on brushed, oiled again, and the stock is

then sorted into grades. Printing or embossing with the box grain and then boarding the leather makes a fine grain which does not readily become smooth. For the shades of dark tan and brown, a mordant of gambier and fustic is used, coloring being effected with basic dyes. This is done best before the leather is fat-liquored, as grease applied before coloring is likely to prevent penetration of the color into the goods. Smooth finish is obtained by ironing or rolling the leather before the seasoning is quite dry. Excellent colors are also obtained by using acid dyes and sodium bisulphate after the leather has been fat-liquored.

*Black chrome oil grain leather.*—This leather is usually made from good plump hides weighing not over 50 lb. each green-salted weight. Splitting is done after liming, or after the sides have been tanned and pressed. In the latter case, re-tanning with chrome liquor is necessary. Neutralizing, washing, and shaving is done in the usual manner, and the leather is then blacked with hematin (logwood) crystals and direct chrome black; and after it has been washed and pressed it is ready to be fat-liquored. It is best to press the leather hard and then to put it into a dry mill and run for a half-hour. Before the fat-liquor is applied, the leather should be spread on a table, grain side up, and the flanks and bellies dampened so that they will not take as much grease as the remainder of the leather.

The following quantities of grease in fat-liquoring are required for 100 lb. of pressed leather: 8 lb. of stearine, 6 lb. of tallow, 2 lb. of degras, and 2 lb. of sod oil. These stuffing greases are put into a kettle and heated to 190 F. The leather is first run for 10 minutes in a hot drum, then given the hot grease and drummed 45 minutes, and 10 minutes with the door off. It is next piled in a box, covered up, and allowed to lie over night. The next morning it is struck out on the flesh side, then on the grain side, and hung up 5 or 6 hours. It is then re-set on the grain side and tacked on frames to dry. In re-setting it is necessary to use a setting slush so that the leather will stick to the table. This is made

of 3 lb. of degras and 3 quarts of finishing oil, melted together; then dissolve 1 lb. of soap in 1 gallon of water, and stir in the degras and finishing oil. Add enough cold water to make 6 gallons of the mixture.

When dry on the frames, the leather is shaved lightly on the flesh side in the shaving machine, which gives a clean back. A clean, dry, and greaseless back is essential on this leather, as shoes made from it are frequently unlined. The leather is trimmed and staked, then boarded from back shank to neck and from front shank to tail, this making what is known as English grain. After it has been thus grained, the leather is given two coats of finish and hung up until the finish is dry. It is then measured and grained lightly, just enough pressure being applied to bring up the grain. The leather is now ready to be sorted and tied into bundles.

*Leather for sporting goods.*—Chrome leather is used in the manufacture of sporting goods, such as punching-bags, footballs and baseball gloves. Light hides and kips work into this class of stock more profitably than larger or smaller skins. The flesh splits taken from the hides can be finished into cheap glove and mitten leather.

After having been tanned, washed, and shaved, the leather is colored and fat-liquored. The use of sulphonated oil as a fat-liquor, or a mixture of it and neat's foot oil, is especially suitable for this leather. For the shades of color most in demand it is advisable to fat-liquor first and color afterwards.

When dry, the leather is dampened, staked, and tacked out to dry. It is then trimmed, re-staked lightly, and put into a dry drum together with 5 lb. of talc for one dozen skins and drummed two hours. The grain is then brushed with a soft brush and the skins are measured and sorted.

**Finishing vegetable-tanned grains into black leather.**—The goods after being fully tanned, are washed, struck out, shaved, and re-tanned with sumac at 90° F. The leather is put first into a sumac liquor which has been used for a previous pack, and after 24 hours is placed in a new bath. It is then horsed-up, set-out, oiled on the grain with cod oil or

other leather oil, hung in the air, struck out on the flesh, and fat-liquored on the flesh with a mixture of degras and cod oil, applied sparingly in order to avoid greasy grain. In place of this fat-liquor, the following may be used for 100 lb. of leather: 5 pints of cod oil, 5 pints of moellon degras, 5 lb. of soap, 5 oz. of borax, and 15 gallons of water. After fat-liquoring, the grains are struck out on the flesh and grain and dried, stored a week or two, and then dyed black. If the grain only is to be blacked, it is brushed with a direct leather black. The grain is then oiled, and the leather is partly dried, boarded in several directions, laid in a pile over night, cleaned on the grain with a little barberry juice, dried, and rubbed with a soft flannel rag. To obtain a bright finish, a glaze seasoning is applied; and when dry, the grain is glazed, boarded again, given another coat of finish, dried, glazed, and finally boarded again. Where smooth grain is desired, boarding is, of course, omitted. The flesh side may be stained by the addition of a suitable dye to the fat-liquor, and the grain blacked afterwards.

*Finish for bright boarded grain leather.*—Dissolve 4 oz. of logwood extract and 4 oz. of gelatine in 3 gallons of soft water. When cold, add 2 oz. of ammonia, 1 gallon of beef blood, 1 pint of milk, 2 oz. of ferric chloride, and 2 oz. of spirits of camphor. Mix 1 oz. of gelatine in milk before putting into the finish; then stir together, putting in the iron and camphor after the other ingredients have been worked together.

The dry leather should be dampened, staked, and tacked; and the grain should then be dampened with warm, weak logwood liquor before it is finished. As soon as the grain is dry, apply the first coat of seasoning; dry again, and polish on the jack. After polishing, dampen the leather and let it lie awhile to allow the dampness to penetrate evenly; then grain from tail to foreshank and from hindshank to top of shoulder, and soft-board crosswise on the flesh side. Dry the leather, and then finish graining by boarding on the grain side crosswise and lengthwise. Next apply two light coats

of seasoning, the first being allowed to dry before the second is added. When the last coat is dry, the leather is ready for the last polishing. Sufficient pressure should be used to cause the grain to disappear and bring the brightness from the bottom of the impression of the print. After polishing, the leather is staked and given the last graining. Grain four ways on the grain side—very lightly—and the result will be a fine, even grain, very black and glossy. The finishing touch is a light coat of hot oil, made of equal parts of raw linseed, paraffin, and sweet oils. After being oiled, allow the leather to lie in a pile for a few days before it is sorted and rolled into bundles. Dull-boarded leather is made in the same manner, except that dull dressing is used. Printed grains are made by printing and graining the leather with the grain figure desired.

**Finishing rough leather.**—Stock selected for bags and suitcases should be of a good light color, of soft tannage, and free from scratches, grubs, salt and bark stains. The best results are secured from sides that measure, when finished, about 24 sq. ft. each, and 14 lb. weight to the side should be the limit. The rough leather is weighed and trimmed, 25 sides making a pack of convenient size. Wet the sides down over night, and stone them on the jack in the morning. Skive them on the belt-knife machine and split them from 2 to 4½ oz. per foot. The lighter leather will be the more suitable for suitcases and the heavier for bags.

The next process is washing with borax preparatory to bleaching. If the leather is dark, dirty, and greasy, more borax is required than for light, clean stock. Use 25 gallons of warm water, and from 2 to 6 lb. of borax for the 25 sides. Run the leather in this borax solution for 15 minutes, then drain off the water and wash the leather in warm water to remove the surplus tannin and borax. The leather is now ready for the acid bath. Mix 1 gallon of sulphuric acid with 40 gallons of water and run the hides in the solution for 10 minutes; drain the liquor out of the drum, and wash the leather with 3 to 4 changes of water, using 25 gal-

lons at each change. The leather should be washed until no trace of acid can be detected in the water coming from the drum. More or less acid may be used, according to the requirements of the leather.

Next put the leather into the clean drum, with a strong, hot sumac liquor, and drum for a half-hour. Some tanners add ½ pint of tin crystals and a pint of hydrochloric acid to the sumac liquor; others add only salt. Take the leather out, and place it in piles for 24 hours; then rinse it in clear warm water to wash off the sumac, and strike the flesh out hard. If the sides are to be colored in a drum they are now in good condition for that process. If they are to be dried first, give them a coat of cod oil on the grain, and tack them on frames to dry. The leather should be run in the color bath for 30 minutes, then rinsed and horsed-up. One way is to hang it up to dry after rinsing, without setting out as this works the dye into the flanks and sides. When dry, the leather may be dampened, set out on the grain, given a light coat of oil, and tacked on frames to dry. Another way consists of fat-liquoring rather lightly after coloring, using fig. soap and egg-yolk in equal proportions; next horsing-up the leather for 24 hours, slicking hard on flesh and lightly on the grain, then tacking out to dry. When dry, the leather is seasoned and finished. If russet leather is required, the stock, after rinsing from the sumac bath, is finished without coloring.

After the sides are dry, stake them and give the grain a coat of cornmeal filling. This is made by boiling slowly for a half-hour 1 quart of cornmeal in 1 gallon of water. Allow the paste to cool, then strain, and give the leather a good coat, rubbing it in hard. When it is struck in well, roll the leather and hang it up to dry. It is then ready for the seasoning.

For colored and russet leathers, the following finish may also be recommended: Dissolve 4 oz. of blood albumen by standing in 1 gallon water over night; boil 4 oz. of granulated gelatine in 1 gallon of water and let it cool; and mix ½ pint of white varnish shellac with ½ pint of ammonia. Mix

these three materials together, add enough water to make 3 gallons, and let this finish stand a week before using it. Apply with a sponge. For a bright finish, dry and glaze; and for a dull finish, give two coats and roll while wet; then hang up to dry, and when dry, apply another coat. Finish by graining, printing, or embossing. For a black finish, use any of the formulas given under calfskins.

**Finishing imperfect grains into patent tipping.**—Among the stock tanned for bag and case leathers, on which a perfect grain is essential, after the hides are split grains are found which are imperfect and therefore not suitable for finishing with the more perfect ones. Such grains can be made into patent tipping, on which, the grain being buffed off, such imperfections are not noticeable. The grains are taken from the splitting machine and washed in 50 gallons of warm water to which 1 or 2 lb. of borax or washing soda has been added for each 50 sides. The leather is washed in this water for 30 minutes, then in cold water for 15 minutes.

Re-tanning is done with a one-bath chrome liquor, the grains being run in a drum with the liquor for 2 hours, then piled down over night. The next morning they are washed in running water for 20 minutes. Three quarts of extract of fustic are next dissolved in a half-barrel of water, and the leather is drummed in the solution a half-hour, after which it is fat-liquored.

Fifty sides may be fat-liquored with 2 lb. of neutral chip soap and 9 lb. of the best moellon degras in 50 gallons of water. The leather is run in this fat-liquor a half-hour, then piled down over night. To prepare it for finishing it is set out and tacked on frames to dry. When dry, it is buffed and staked, and is then in condition to be japanned and finished.

**Dressing for leather goods and furniture.**—A dressing for goods made of leather and for leather furniture is made as follows: Put $\frac{1}{4}$ pint of hot water, $\frac{1}{2}$ oz. of annetto, and $\frac{1}{2}$ oz. of white soap shaved fine, into a bowl, and place the bowl in a pan of boiling water. Into another bowl put $\frac{1}{2}$ oz.

of beeswax, shaved fine, and put it in the pan of boiling water. Stir the contents of both bowls until they are melted, then remove them from the fire. Into the melted wax stir $\frac{1}{4}$ pint of turpentine, $\frac{1}{4}$ pint of paraffin oil, and then the mixture of annetto, soap, and water. Beat the mixture until it is cold, then put it in a fruit jar for future use. This preparation may be used on brown or red leather. First wash the leather with hot milk, using a soft cloth or sponge. If the leather is faded, the dressing may be made darker by using two or three times the quantity of annetto. For dark green or black leather, a little logwood should be added to the dressing.

**Removing spots and stains from leather.**—Colored leather, which is simply soiled or dirty and not stained, may be washed off with warm castile or ivory soap suds, then dried and rubbed. A dirty water stain is sometimes taken out with the juice of a lemon, which is the mildest acid that can be used. Vinegar also is employed for water and other stains.

An oil spot may be removed by dipping a piece of rubber in naphtha and rubbing over the spot. Another way is to cover the spot with cement such as is used in shoe factories, and after the cement has dried for an hour or a little longer, rub or roll it off with the finger. If a little remains, go over it with the rubber dipped in naphtha. For dirt from the hands, a little oxalic acid well diluted may be used. Wash the dirt off and then wash with soap and water, and perhaps apply a little of the finish. An aniline stain cannot very well be taken out, but it may be helped somewhat with a rubber. Some of the aniline can be washed off with a regular wash, as with soap and water. However, the stained part of the leather cannot be made to look like the rest, because it has soaked through more or less. It depends much upon the leather as to how far aniline will penetrate. There are various preparations available which shoe manufacturers use for stains, and some of these are employed to clean and polish vamps in one or more operations. Leather which becomes stained or discolored should be re-dyed into black stock.

Grease spots sometimes get onto the leather from oil from pulleys or shafting, and may be taken out with shoemaker's cement and chalk. Put the cement on first, then lay the chalk on, and work both into the leather with the flat of a knife or by other means. The cement will eat into the grease, and it should stay on until the grease comes out, even if it takes 24 hours or more. Use pure rubber cement for this purpose, as a cheap article is likely to stain the leather. The cement will dry after a little while so that it can be rolled off.

Another method is to place a piece of cloth or some cotton waste saturated with naphtha over the spot. This is covered with another cloth to prevent too rapid evaporation. More than one application may be necessary as the grease or stain must dry out gradually. It is the naphtha in the cement that removes the grease; and it might be applied in any other form, provided not enough is used to bleach the leather. Slight spots may be rubbed out dry with a cloth saturated with naphtha. Ether is sometimes used.

White ooze leather, and possibly also white grain leather, that has become soiled, may be cleansed with salts of sorrel (potassium acid oxalate, which can be procured at any drug store). Cold water is applied to the leather, washing it all over. A mixture of salt and lemon juice or salts of sorrel, is then rubbed over the soiled portion, with the result that all the spots, stains, and dirt marks disappear, and the leather is once more white. The leather should always be washed with water, which must be rubbed over the entire skin; but the mixture of salt and lemon juice is applied only to the soiled portion.

**Bright blacking varnish for shoe leather.**—This varnish is useful in producing a bright polish on grain shoe leather of any tannage. Dissolve in a bottle, tightly corked, 1 oz. of caoutchouc in 1 oz. of carbon bisulphide, and let the solution stand for a few days. Next dissolve 3 oz. of orange shellac, $\frac{1}{2}$ oz. of gum sandarac, $1\frac{1}{2}$ oz. of gum mastic, and 5 oz. of pure Venetian turpentine in 2 quarts of alcohol. Add the turpentine after the other gums are dissolved. When all

three materials are well mixed, add the caoutchouc solution. Put the vessel containing the complete mixture in another vessel of hot water, and heat to about 120° F. Then add 1 oz. of spirit soluble black. Keep the whole for about an hour in water at 120° F. Then put it in a jar, cork tightly, and let it stand at least two weeks before using, as it improves with age.

Two thin coats should be evenly spread on the grain with a sponge, and well rubbed in with a fine sponge or with a soft hair brush in a warm room. Let the first coat dry before applying the second. After the last coat is absorbed, glaze the leather slightly by hand to produce the soft feel the stock had before the varnish was applied.

**A waterproof leather dressing.**—Petrolatum, 4 lb.; Burgundy pitch, 4 oz.; rosin, 2 oz.; ivory black (dry), 6 oz.; and beeswax, 4 oz. Melt the rosin, pitch, and beeswax together, then add the petrolatum, and when it is melted, stir in the ivory black and continue stirring until the mixture is cold.

Apply the dressing to the leather with a soft cloth and rub in well. If the leather is dirty, wash it with a sponge and a little soap before applying the dressing. This gives a good black but not a polish, and if used properly, it will make leather soft and pliable, no matter how hard or water-soaked it has become. A strap treated in this way may be immersed in water for a week without absorbing any. Used as shoe dressing, it renders the wearing of rubbers unnecessary.

**A harness blacking.**—Mutton suet, 2 oz.; yellow wax, 6 oz.; powdered sugar, 4 oz.; yellow soap, 2 oz.; lampblack, 1 oz.; indigo, 4 oz.; and oil of turpentine, 4 oz. Dissolve the soap in the water; add the other ingredients, except the turpentine; melt and mix thoroughly together; then add the turpentine. This mixture is applied with a sponge and polished with a brush.

**Blacking for vegetable-tanned leather.**—The following is a good blacking for heavy shoe and harness leather: copperas, 9 lb.; epsom salts, 4 oz.; acetic acid, 6 oz.; and nutgalls, 1 oz. Put these ingredients into 2 gallons of soft water and

boil until dissolved; then put the solution into a barrel and add 40 gallons of water; stir thoroughly, and the blacking is ready for use.

If the leather has a loose and open grain it is advisable to use 4 or 5 gallons of strong gambier liquor in place of the same amount of water. This will tighten up the grain and prevent it from piping when finished.

**Sigs for greasy leather.**—To make one barrel of sig to clear the grain of greasy leather before applying logwood, use the following: salts of tartar, 12 lb.; sodium dichromate, 5 lb.; ammonia (26°), 1 quart; and water, 40 gallons. Boil the tartar and dichromate in 12 gallons of water, and when dissolved, make up to 40 gallons, and then add the ammonia, stirring thoroughly. If kept for any length of time it may be necessary to add more ammonia.

An excellent sig is also made as follows: Use a 50-gallon barrel, and boil 12 oz. of caustic soda and 12 oz. of salts of tartar in 12 gallons of water, and when dissolved, fill the barrel with cold water.

**Finishing splits**: *Chrome-tanned splits.*—The splits taken off chrome-tanned hides may be finished into gusset splits or glove and mitten leather in much the same manner as the grains. First they should be leveled on the split side and then shaved to a uniform thickness. It is generally necessary to re-tan by drumming first in hot water and then in a one-bath chrome liquor for 3 or 4 hours, leaving them in the liquor over night. They should then be drummed for 30 minutes, taken out, and placed in smooth piles for 48 hours. Washing is the next process, which is done in the same manner as grains are washed and neutralized; after which the splits are colored. For black leather, a direct color is preferred. There are special black ooze dyes which are satisfactory for chrome splits, dyeing being effected in one operation, this rendering the use of logwood unnecessary. Some dyers prefer to use logwood first and top with the direct black. The general procedure when both dyes are employed is to use 1½ lb. of logwood crystals and 4 oz. of fustic extract in 12 gal-

lons of water for 100 lb. of leather. This liquor is used at 125° F., and the splits are drummed in it for 30 minutes. Then 12 oz. of direct black is dissolved in 2 gallons of boiling water, the solution is poured into the drum, and the splits run 15 minutes longer. Any suitable striker is next added to the drum, and after 10 minutes the dyeing is completed. The use of titanium-potassium oxalate is recommended for this purpose. The splits should be washed thoroughly after they have been dyed, pressed, and fat-liquored. If the leather is for mitten stock and some shade of yellow is desired, a yellow dye suitable for chrome leather should be employed. Special glove dyes are procurable with instructions for their use. For mitten leather, the splits are fat-liquored once; for gusset splits, twice. After applying the first fat-liquor, hang the splits up to dry; when dry, put them into the drum with hot water, and run it 40 minutes; then drain off the water and give the leather the second fat-liquor. Let the splits drain over night; then hang them up to dry. To finish the stock, put it in the drum with warm water, and run until soft and moist, or dip into hot water and place in piles over night. The next day tack the leather on boards, and when dry, run in a dry drum until soft.

Another way to handle splits is to mill them after the second drying until they are soft, then stake them as smooth as possible and measure them. Tacking secures the greatest measurement and eliminates the "bag." Splits for mitten leather are treated in the same manner. Softness is, of course, the most essential quality of glove leather, and is secured by thoroughly tanning and re-tanning, and by applying plenty of fat-liquor.

Gusset splits are produced not only in black but also in colors. There are dyes for this which can be used either before or after the splits have been fat-liquored and dried. Some dyers fat-liquor and color their leather at one operation: but the usual practice is to dye first with basic colors and fat-liquor afterwards. Dyes that are not stripped from the leather by the fat-liquor are, of course, required. Good

penetration of the color is secured by using acid dyes in an ammonia bath, and after 20 minutes of drumming add formic acid to the drum, which ensures uniform color throughout the goods.

*Finish for the black.*—When splits are dry after stuffing and setting out, pack them down in a pile for a few days; then whiten lightly on the back and to a fine face on the flesh side to be finished. Now trim the edges and place the stock flesh side up on a table for the back finish. Make a paste for the back finish by mixing 2 lb. each of red lead and yellow ocher and pour in slowly and stir 1 gallon of cold water. Dissolve 1 lb. of corn starch in 1 gallon of cold water. Boil the red lead and ocher, pour in the starch, stir well and boil thoroughly. Let the finish cool, which is then ready for use. Spread an even coat on the flesh with a soft brush. Hang the stock up to dry and then glass with a jack. If the paste is too thick, add more water; and if it is not the color desired, change the proportions of lead and ocher to suit.

*Soap black.*—To make a soap black, dissolve 12 lb. of common soap in a half-barrel of water, with 2 lb. of potassium carbonate. Add from 12 to 15 lb. of lampblack according to quality. Boil slowly after the lampblack has been mixed in. Next add 2 pails of strong logwood liquor and 1 lb. of indigo, and boil and stir thoroughly; then fill the barrel with cold water and add 1 pint of chloride of iron. Spread this black with one brush and rub it in with another. Sweep any smut off with a duster. If the glassing is to be done by hand, glass immediately after blacking. If the stock is glassed with a jack, hang the splits up after blacking before glassing. When the black is dry, they are ready to be jack-glassed.

*Flour paste.*—For pasting, make a stiff flour paste by mixing 4 quarts of flour in 2 gallons of cold water. Add a little water at a time and stir to prevent lumps forming. When thoroughly mixed, boil for 10 minutes with live steam; then add ½ lb. of tallow and ½ lb. of common soap, and boil until thoroughly cooked. Let the paste cool, and spread evenly a

fairly heavy coat with a fine sponge. Hang up the splits, and after the paste is dry, glass either with jack or by hand. If the splits will stand it, they can be oiled over the most solid parts on the black side. Good judgment must be used in oiling so as not to have the stock show the oil after it is finished.

For finishing, give an even coat of gum-tragacanth dissolved to a thin substance. When dry, the splits are ready to be sorted.

*Finishing splits into Goodyears, chair splits, etc.*—The splits are taken from the splitting machine and trimmed, then put into a mill with a weak tanning liquor of 6 to 8° bk., and milled one hour. This process breaks up the crust made by the belt-knife, and opens up the splits so they will take the re-tan liquor. When milled, they can be re-tanned in a mill or put back into the tan-yard for 3 weeks, using a strong liquor. The splits should be pulled out of the liquor every other day and allowed to drain for 4 to 6 hours, the liquor strengthened, and the splits put back one at a time. If the tanning is done in a mill, it will take about 6 days to make a good split. The splits should be milled in strong liquor about 2 hours each day, and then left in piles the remainder of the day. This operation is repeated daily for 6 days, when the splits will be fully tanned.

When tanned, the splits are sorted, and the heavy ones may be worked into flexibles or Goodyears, and the light ones into chair seats.

If flexibles are to be made, the splits are put into the mill (after lying 48 hours after the last tanning) and given a treatment in a strong solution of epsom salts. This gives a light color without removing any of the tan. This solution is made by dissolving 75 lb. of the salts in 50 gallons of water. Use about 12 gallons of the solution to 8 splits. Drum them 30 minutes, then pile them down over night. The next day set out and hang up to dry. When dry, dip the splits in warm water and lay them in piles for 24 hours; then apply a coat of Irish moss and soap, roll hard, and hang up to dry. When dry, trim and measure.

If Goodyear splits are to be made, the stock must be trimmed to have the proper bend for this product. The trimmings are finished in the same manner as the flexibles and sold for cheap insoles, the bend being leveled on the splitting machine. Bends for Goodyears must be of uniform substance. After they are leveled, they are fat-liquored with soap and cod oil, using ¼ lb. of soap and 3 lb. of oil to each 100 lb. of leather. Run them in this fat-liquor and pile them down over night. Then make up a clearing liquor of 2 lb. of lactic acid in 16 gallons of water, and run the bends in this for 10 minutes; then dry them out, being careful to have them dry flat.

When they are dry, make up a paste of 3 lb. of glue, 1 lb. of white soap, 1 lb. of Irish moss, and 1 quart of finishing oil. Soak the glue over night in 3 gallons of water. In the morning add the soap, moss, and oil, and boil for an hour, then add enough water to make 10 gallons, and strain. When cold, give the splits a good heavy coat of this paste and hang them up until it has struck in; then roll it hard and treat the other side the same way. When dry, they are finished.

If the light splits are to be put into chair leather, they are leveled on the machine, then put in a drum and given a milling in sumac liquor, using 1 pail of sumac in 12 gallons of water for a dozen splits. Mill for one hour; then pile them down for 24 hours, and set-out on both sides and hang up to dry. Do not hang over sticks. Trim off all the shanks and thin edges. When they are dry, make up a filling paste of ½ lb. of corn starch, ½ lb. of dextrine, and 1 lb. of casein which has been soaked over night in 3 gallons of water, and boil this mixture slowly for an hour. While boiling, add ½ lb. of ivory soap cut into fine shavings. This will make 10 gallons of paste. An acid dye of any color desired can be added to the paste and the splits made into any color. They should be given a good coat of this paste, which should be put on smooth, and when about half-dry, the splits are rolled hard and dried, when they are in condition to be embossed.

After embossing they are given a coat of waterproof finish made by cutting shellac in alcohol, and adding aniline soluble in spirits to the finish; using an aniline of the same color as the splits, the finished goods will have a rich color. These splits are also often worked into cheap suitcases and bags.

*Grain leather from splits.*—Imitation grain leather may be made according to the following instructions: The splits should be run through a borax bath in a drum, 5 lb. of borax being sufficient for 25 splits, medium size and weight. Heat 8 gallons of water to 75° F., and drum 20 minutes. Then make a bath consisting of 8 gallons with $\frac{1}{4}$ lb. of sulphuric acid. Drum the splits in this for 15 minutes, then rinse in clean cold water, washing until the acid is all removed from the goods, then fat-liquor with 5 lb. of chip soap and $2\frac{1}{2}$ lb. of neat's foot oil. Boil the soap in 3 gallons of water and add the oil, together with 1 oz. of sal soda. Cool to 80° F. and run the goods 30 minutes; then horse-up to drain. Next slick hard on both sides and glass on split side. Oil with linseed oil; then hang up or tack out to dry.

When dry, the splits are ready to receive the color—black, brown, or any other color. When colored and dry they are ready for the moss or linseed solution. A good dressing is made from equal parts of glue and gelatine. Apply when warm, taking care not to have it too thick, and spread it on evenly. After the dressing has dried, the goods are embossed either in imitation of some grain or finished plain. This is a very necessary operation, after which the embossed side is given a coat of waterproof filling made of wax and rosin dissolved in turpentine. This is the final finish, and the leather is now ready for use.

**Materials used in finishing leather.**—In the finishing of leather, materials are used that are neither oils, dyes, nor mordants, and are classified as finishing materials, their function being to fill the pores and surface of the leather. They may be divided (1) into products of animal origin, such as blood and egg albumen, casein, gelatine, isinglass, etc.; and (2) products of vegetable origin, such as gums (arabic, traga-

canth, and shellac), starches, dextrines, moss, etc. Some of the materials in common use will be briefly considered:

*Blood.*—Large quantities of bullock's blood are used in finishing leather, indeed, many seasoning liquors are nothing but logwood extract dissolved in warm water and then thickened with 5 to 10 per cent of blood. The best material to use is what is commonly known as de-fibrinated blood, which is blood that has been allowed to clot spontaneously by standing for several hours in a warm place, and from which the clot is then filtered. This de-fibrinated blood is practically a solution of blood albumen. The clot is albuminous but consists of the organized or cellular structure of the blood, that is, the blood corpuscles. The coloring matter of the blood is in the red corpuscles (hemoglobin) and is carried down with them in the clot, while the filtered blood, if care is taken in its preparation, is a straw-colored fluid. To prevent putrefaction a preservative should be added to the blood as soon as it is filtered, carbolic acid or phenol being commonly used. Nitrobenzol or oil of myrbane is also used and is quite as effective, and although it costs a little more it is recommended as it is much less poisonous than the phenol and has a pleasant instead of a disagreeable odor.

*Blood albumen.*—This is made from the de-fibrinated blood by simple evaporation in vacuum pans. The evaporation must, however, be conducted with extreme care so that the temperature does not rise above 130° F., as above this the albumen will begin to coagulate, and when once coagulated, is valueless as a seasoning agent. When evaporated to a paste, the blood is removed from the pans and placed on screens in a warm air-drier. In this drier the temperature is even more important than in the pan, and much albumen is destroyed by overheating. In the United States, however, where animal by-products like blood albumen are controlled by large packers, these preparations are made under scientific supervision, and there is much less damaged albumen on the market here than in England and Europe.

*Egg albumen.*—This is prepared from the white of the egg, by far the largest proportion of the world's supply being manufactured in China from duck eggs, and some in Russia. The great advantage that egg albumen has over blood albumen is its absolute freedom from coloring matter or iron, which amounts to the same thing, as the red color of blood is due to iron. For this reason egg albumen is used in the seasoning of the best qualities of glazed colored leathers. Its cost is always high—5 to 8 times that of casein and 2 to 3 times that of blood albumen—hence it can only be used sparingly and on the highest-priced goods.

*Gelatine and glue.*—These are both used to a considerable extent in finishing leather, and are also interesting to the tanner, as they are, especially the latter, by-products of the tanning industry. While there has been more or less published on the manufacture of these products, the industry has not reached a high state of scientific development. This condition is not the result of lack of chemical investigation, but on account of the technical character of the subject. The present varieties of glue are classified as hide or skin glue, the purest form of which is gelatine, bone glue, and fish glue, and to the last named, isinglass stands in the same relation that gelatine does to hide glue. All of these varieties have a close chemical relation to each other, and are unquestionably complex compounds. Two principal constituents of glue have been separated, and are known as glutin and chondrin, the one being distinguished from the other by different behavior towards chemical reagents. While, for example, both are precipitated from their aqueous solution by alcohol, only chondrin is precipitated by acid, alum, lead acetate, etc. It also contains less nitrogen than gelatine and more sulphur, and, in general, bears a closer resemblance to albumen. The glutin imparts the adhesive property to glue, while chondrin is perhaps more essentially the jelly-forming constituent. By treatment with caustic alkalies, by a sort of hydrolysis as it were, chondrin seems to be converted to a considerable extent into glutin.

Chondrin is found in greater proportion in the bones, skins, and cartilages of young animals, and glutin in the hides of older animals.

*Gelatine.*—As already stated, gelatine is the purest form of skin glue, and is prepared almost wholly from the trimmings of calfskins, particularly the heads and feet, which are regular articles of commerce for this purpose. Curiously enough, these have to be dried first before they will make good gelatine, showing that a certain degree of dehydration is necessary to produce the glue-forming products. The first step in the manufacturing process is the washing of the glue stock. This is accomplished in the ordinary cylindrical washing machine, not greatly different from that used in laundries. The stock is then limed for 10 or 12 days, with frequent changes of the liming liquor. After liming, a treatment with sulphurous acid is given to remove the lime and also bleach the stock. Then the stock is thoroughly washed, and given, according to the most approved processes, a bath of hydrogen peroxide to complete the bleaching and also oxidize any residual sulphurous acid, the presence of even a mere trace of which is now forbidden by most pure food laws. Sometimes phosphoric acid is used in place of the peroxide, its action being simply that of replacing any sulphurous acid which may be chemically combined with the stock. The latter is then given a boiling with live steam, preferably at low pressure, which effects the conversion into gelatine, which is then drawn off and allowed to gelatinize. The jelly is cut into slabs, placed on wire screens and dried by a dry, slightly warmed, air blast. When thoroughly dried, it is ground in a disintegrator mill and packed ready for market.

*Glue.*—The preparation of glue from hides and skins does not differ materially from that of gelatine, except in the selection of the stock; the treatment, however, being more rigorous, and less care is necessary. When bone glue is made, the fat is first extracted, preferably with a volatile solvent, and then the bones are treated with hydrochloric acid to dissolve

the phosphate of lime which constitutes their mineral matter. The stock thus obtained is, after washing thoroughly, boiled to glue in the usual manner.

*Isinglass.*—This is the purest form of fish glue and is obtained from the "sounds" or air-bladders of fish. The best quality is made from the sounds of Russian sturgeon, which are air-dried, thoroughly washed, and boiled to the glue stage. Ordinary fish glue is made from the scales, skins, and other offal from fish. It is particularly adhesive glue, but its odor renders it objectionable for many purposes. In the preparation of all glues, the essentials are the selection of the stock, and care in the manufacturing processes, particularly the avoidance of putrefaction and overheating.

*Casein*, also known as "milk albumen" and "lacterine," prepared in a crude way has been used for centuries as a finishing material on various kinds of upper leather. Without question, much of the early Morocco and Oriental leather was finished with a curd obtained from milk. With cow's milk, the separation of the curd from the whey and its utilization as an albuminous material was, in Scotland a hundred or more years ago, a considerable, if primitive industry. In the analysis of cow's milk a distinction is made between casein and milk albumen, and this distinction is recognized chemically, although commercially, casein is frequently known as milk albumen. The distinction is due to the fact that milk contains two kinds of albumen, the casein or insoluble albumen, which separates from the whey when it becomes sour, or when diluted acid is added to it, and the milk albumen proper, which closely resembles blood albumen, but is only rendered insoluble by acidification and heat.

In commerce, the casein is the only product which is utilized. This is obtained as a by-product of the butter industry. The whole milk as it comes to the creamery is put through a centrifugal separator, in which the lighter cream containing the butter fats is perfectly separated from the heavier skim milk. When casein is to be produced, the skim milk must be acidified to separate it. There are three methods

of doing this: The milk may be allowed to sour spontaneously, in which case lactic acid is developed by the fermentation of the milk sugar, and this lactic acid precipitates the casein; or sulphuric acid or hydrochloric acid may be added to the milk.

For many purposes the casein precipitated by the lactic acid is the best product, but its odor is a serious disadvantage. When milk ferments, not only a lactic fermentation develops but also putrefactive bacteria, especially of the butyric acid class, are present, which attack the casein itself, the result being, even though in slight degree, very bad-smelling compounds, so that for many purposes casein made by this process is almost impossible to use.

Casein precipitated by sulphuric acid is, on the whole, probably the best commercial product. It is troublesome to make, however, as the acid swells up the casein so that it is extremely bulky, difficult to wash, and must be squeezed in powerful presses to reduce its bulk and remove the excess of water before drying. On the other hand, if hydrochloric acid is employed as a precipitant, the casein comes down granular and more compact, can be readily washed, and requires no pressing. The resulting casein is, however, not so satisfactory, it being much less soluble in the alkaline mediums, and the yield is low. The difference in behavior of sulphuric and hydrochloric acids is interesting to the leather chemist because it is analogous to the action observed with these acids in connection with the swelling of hides, wherein sulphuric acid has a pronounced plumping effect, while hydrochloric acid in certain dilutions has just the opposite effect and depletes the hide. When the casein is precipitated and washed it is dried in a warm air blast, great care being taken that the temperature does not rise much over 100° F., otherwise the casein will become insoluble by overheating. The casein is marketed either in the form of coarse scales as it comes from the drier, or is ground to a coarse powder, this product being often mixed with borax or a mixture of borax and bicarbonate of soda, and sold as soluble casein. Since borax is much less expensive than casein, it is more economical to buy the casein

and dissolve it with the aid of borax, the average proportion used being 1 lb. of borax to 9 lb. of casein. For most purposes, equally good results may be obtained with 1 lb. of borax, 2 lb. of soda, and 27 lb. of casein. In the commercial soluble caseins, the proportion of casein is often, for obvious reasons, considerably reduced. If, however, a casein requires more borax than stated to make it dissolve, it is because it has been overheated in drying.

*Irish moss.*—The most widely used glutinous substance of vegetable origin in the finishing of leather is Irish moss, sometimes erroneously called Iceland moss. The true Iceland moss is a lichen which is found on exposed highlands, notably in Norway and Sweden, also in the Alps, and is used to a limited extent in pharmacy. Irish moss or carrageen is found on all the rocky shores of northern Europe, and is particularly abundant on the west and northwest coasts of Ireland. In America, large quantities are gathered off the shores of Scituate, Massachusetts.

When fresh, the plant varies in color from light yellowish-green to bright purple and purplish-brown, but after it is washed and dried in the sun it becomes lighter colored, of a yellowish or brownish-white shade. Viscous and fleshy when fresh, it dries to a semi-transparent, horny substance, the branching form of the plant, though somewhat shrunken, being preserved. The preparation of Irish moss for the market is extremely crude, and it usually contains considerable quantities of sand and small shells. It is generally possible to purchase moss which has been prepared with more care and is reasonably free from these impurities at a little above the lowest market price, and on account of the quantities used this course is often the most economical. Large quantities are also sold in the ground form as a coarse powder, but the objection to this is the probability that the product is adulterated with corn starch.

*Algin.*—In England, algin on a large scale is extracted from seaweed and sold in its purified state for purposes of leather

dressing. The method of preparation is described by Lamb (Leather Dressing, p. 277) as follows:

> The dried weeds are first washed thoroughly to remove as much inorganic matter as possible, and are then dissolved to form a thick jelly in a boiling solution of caustic soda. It is assumed by this treatment that an alkaline salt—sodium alginate—is produced; from this salt, by the addition of acid, the algin, or alginic acid, is precipitated. The precipitated algin is then mixed with a fresh portion of alkaline salt to form a more nearly neutral alginate and in this form is offered to the trade.

British reports have been, as a rule, favorable to the product, but it never has been offered or used extensively in the United States until recently, when the Hercules Powder Co. undertook its manufacture at one of its Californian plants. It is now also being sold in fairly large quantities by another firm under the trade name of "lissom."

Algin is specially recommended for finishing skivers for hat leather; also for bookbinding and furniture leathers. Its action is much more uniform than that of the raw moss, and its solution keeps better, and it is more adaptable for various purposes. The addition of a small quantity to dye solutions as a thickener in table coloring is advocated as giving results superior to those obtained from flaxseed and gelatine which are usually employed. It can, however, be used only with acid dyes, since it precipitates the basic colors.

*Shellac.*—This is obtained from gum-lac or simply lac, which is an exudation occurring on the small twigs or branches of several varieties of East Indian trees. It is produced by the puncture in the egg-laying operation of the female insect known as the *coccus lacca*, an insect similar to that from which cochineal is obtained. The gummy exudation following the puncture has the function of furnishing a protective covering for the eggs and providing food for the maggots. The female insect expires after laying eggs and is also enclosed by the gum. The best grades of lac are obtained by breaking off the twigs before the eggs are hatched. These twigs come into commerce as "stick-lac." By immersion in boiling water, the gum-lac is melted from the twigs, and the bodies of the dead insects, eggs, etc., are removed by straining. The melted lac is then

spread out into sheets by pouring it on a slowly revolving surface, the sheets broken into small pieces constituting shellac.

*Button lac.*—This is obtained by simply pouring the melted gum on a flat surface so that it solidifies in small disks. Shellac is soluble, as is well known, in alcohol, the solution being known as shellac varnish. As the solubility of shellac in alcohol, however, decreases rapidly with decrease in strength of the latter, care should be taken, if a tanner or leather finisher desires to "cut" his own shellac, that he use at least a full 95 per cent alcohol; also that he keep his alcohol and varnish well sealed, as high-strength alcohol rapidly dilutes by the absorption of moisture from the atmosphere. In case the alcohol has become diluted, it may be freed from water by shaking it up with fresh quicklime, and then decanting the clear liquid. Shellac is soluble in aqueous solutions of the alkalies, and also in a solution of borax, and for many purposes these solutions, especially that in borax, can economically replace the alcoholic varnishes; that is, for those purposes where shellac is used for its adhesive or filling properties.

*Pyroxylin.*—Collodion, soluble cotton, banana liquid, etc., are names given to the solution of nitrated cellulose in various solvents. Nitrated, or nitro, cellulose was first known in its highest state of nitration as guncotton, a high explosive, which is chemically a combination of the cellulose molecule with three nitric acid radicals. This product is obtained by immersing thoroughly dried and purified cotton fiber in a mixture of high-strength nitric and sulphuric acids. It was discovered later that by immersing cotton in a mixture of somewhat less concentrated acids and at a higher temperature a much less explosive compound was obtained. This compound, which is composed of about equal quantities of tetra-nitrocellulose and tri-nitrocellulose, has the added advantage of being soluble in mixtures of ether and alcohol, acetone and amyl-acetate, guncotton itself being insoluble or soluble in them with difficulty. On evaporation of the solvent, a very elastic coating or varnish is left behind, the nature of this varnish, however, depending largely upon the solvent employed. The amyl-acetate

leaves the toughest and most elastic varnish, and as such is largely used in the finishing of enameled and patent leathers. On account of its characteristic odor, the amyl-acetate solution is frequently called banana liquid, but owing to the high cost of the amyl-acetate, the solutions are often diluted with considerable quantities of acetone. Amyl-acetate is obtained by the action of glacial acetic acid on amyl-alcohol in the presence of sulphuric acid or potassium bisulphate.

The amyl-alcohol is the chief constituent of fusel oil, a by-product in the manufacture of ethyl or grain alcohol, the largest quantities being obtained by the fermentation of a mash made from potatoes. Besides the use of these cellulose solutions for patent-leather manufacture, their employment in making a cement for joining the laps of chrome-tanned belt leather is of importance to tanners. For this purpose a highly concentrated solution in acetone is generally used, and the best cements contain also ½ to 1 per cent of red oil or castor oil, which seems to have the effect of making the joint less brittle. Indeed, it is this small quantity of oil which has been the secret component of many of the commercial cements, and the ignorance of its presence prevented belt manufacturers from successfully making their own cement.

# CHAPTER XVI

## WOOLSKINS AND FURS

In the preservation of pelts where the natural hair is to be retained, the processes of manufacture, of course, differ from those already described. There are many operations, however, which are similar to those given in the chapter devoted to leather manufacture, and as the preparation of furs is a branch of the leather industry, some mention of the subject should be made in this volume.

Considerable skill is required in the preparation of furs, and in many cases extreme care must be exercised.

**Tanning woolskins:** *Soaking, washing and scouring.*—Sheepskins that are to be tanned with the wool on, should be good fresh skins. Old, stale skins should be avoided, as the wool is likely to slip, for which there is no remedy. The skins should be trimmed to remove the valueless parts, then fleshed and washed. After washing, which is best done in a wash wheel supplied with running water, the pelts should be run through a burring machine, which removes all the burrs, twigs, etc. Copper sulphate is of assistance in soaking dry pelts, 1 oz. to 15 gallons of water being sufficient, it acting as a germicide. Some skins merely require to be washed with borax and soft soap; others need thorough scouring, which is done to make the wool as clean and white as possible before the skins are tanned. It is much easier to wash the wool clean before than after tanning, as the alum, salt, and other tanning materials set the dirt and grease, and make their removal more difficult.

Scouring is done by laying the skins on a sloping table, applying the scouring solution first to the flesh and then to the wool. The liquor may be made of a strong solution of soft soap, to which a little ammonium carbonate is added; or it may be a solution of soap, soda ash, and salt made in the fol-

lowing manner: Add two buckets (14 quarts per bucket) of soft soap to 50 gallons of water in a vat or tub, then put in a half-pail of soda ash; turn on steam and boil the soap and alkali until they are dissolved; add one pail of salt and enough water to make 200 gallons of liquor. The salt helps to bleach the wool and also counteracts the caustic action of the soda ash.

The scouring liquor is first well worked into the skin with a brush, after which it is poured into and worked thoroughly among the wool. The skins are next placed in waste scouring liquor, rinsed in warm water, and then scoured again as much as they seem to require. They are then rinsed in water until free from soap, next wrung out or drained thoroughly, after which they are tanned.

*Liming.*—The following process of liming is satisfactory: A solution of 1½ per cent of caustic soda is made into a thin paste by the addition of talc, china clay, or some similar inert material. This paste is applied to the flesh side, the skins folded up—flesh in—and allowed to stand 4 or 5 hours. They are then thrown into a 4 per cent solution of calcium chloride (4 lb. of calcium chloride in 10 gallons of water) and left several hours, usually over night. The pelts should then be washed in water in the drum and de-limed with lactic acid. About 4 oz. of lactic acid per dozen skins is usually sufficient. The skins are now ready for tanning (from the Leather Trades Year Book).

*Tanning.*—The tanning may be done with a paste of alum, salt, and flour. Heat 2 gallons of water to near boiling point, and stir in powdered alum until the solution is very bitter to the taste. Add half as much salt as alum, and allow the solution to cool. Mix some flour with water and add the paste to the alum and salt liquor. This tanning paste makes the flesh nice and white. If yellow color is desired, add 1 lb. of gambier to the paste, this having been dissolved separately.

The skins are spread on a table, flesh side up, and the paste is spread on evenly and liberally. The skins are then laid flesh-to-flesh, or folded half over the other half, and left until

the next day. The paste should be applied every day for a few days. The skins should then be hung up to dry, and as they dry, worked and staked until soft and dry. One pound of rolled oats may be used in place of the flour, the solution of alum, salt, and oatmeal being boiled several minutes. The wet skins may also be tanned by using a mixture of powdered aluminum sulphate and salt—2 parts of the former and 2 parts of the latter—or a mixture of powdered alum and salt. This can be used dry, and rubbed into the flesh side of the skins every day for several days, when the skins will be fully tanned.

Another way to tan the skins is to dissolve 8 oz. of aluminum sulphate and 6 oz. of salt in a gallon of warm water, and apply several coats of the solution.

A convenient way to tan the skins is to stretch them on frames and apply the paste or dry powder to the flesh side.

Alum-tanned skins, before drying, should be given a solution of soap or stearine which serves to fix the tannage so that it cannot be so easily removed by washing. Egg-yolk is also used for the same purpose. Tanning can also be done by immersing the skins in a solution of alum and salt, then drying them. Flour added to the tanning paste makes the skins softer and whiter.

After the skins are dry and soft it is advisable to re-scour them. This should be done on a table in about the same manner as before tanning.

*Bleaching.*—A permanent white can be obtained by bleaching the skins with hydrogen peroxide. The bleaching bath is prepared as follows: Make a 1 per cent solution of sulphuric acid by mixing 10 lb. of acid in 100 gallons of water. To this solution add 7 lb. of sodium peroxide, stirring constantly. The liquor is then tested with litmus paper, and peroxide or acid is added as required until the solution is neutral; 4 lb. of sodium silicate, previously dissolved, is then introduced. The skins are stirred in this liquor for an hour; then taken out, passed through a weak solution of sulphuric acid, washed, drained, re-tanned if necessary, de-greased, and dried. When

dry, they are softened and run on an emery wheel to clean the flesh. Re-tanning is done by applying a solution of alum and salt to the flesh sides.

Bleaching may also be done with potassium permanganate and sulphurous acid. The skins are washed and placed in a solution of permanganate made by dissolving 18 oz. in 120 gallons of water warmed to 95° F. The skins are stirred in this solution until the wool is a good, rich brown. They are then removed and drained, and next placed in a bath of sodium bisulphite made of 120 gallons of warm water, 7.3 quarts of liquid 33 per cent bisulphite and 6.6 lb. of hydrochloric acid. In this liquor they are worked until they are sufficiently bleached. They are then rinsed, dried and finished.

*De-greasing.*—Most of the grease in the skins may be removed by plastering the flesh side with a paste made of whiting and water. The skins are tacked out wet and the paste of whiting is applied. The skins are then placed in a warm room and dried. The grease is absorbed by the whiting. The plaster should be scraped off and another coat applied. This should be done until the paste dries clean and white. The flesh is then washed clean, and a mixture of alum and salt is applied to replace the tanning material removed by de-greasing and washing.

Some grease may be removed by brushing the skins with benzine, then rinsing off with hot sumac liquor.

De-greasing may be done with benzine in the following manner: Make a wooden tray about 1 foot deep, 3 feet wide, and 4 feet long, with a rack about 1 inch thick to keep the skins off the bottom of the tray. Only the leather should be in the benzine. The lid of the tray should be made to fit in a slot, and be filled with water to prevent evaporation of the benzine. The skins are then dried and finished.

*Tanning with formaldehyde.*—The skins limed, and then de-limed with lactic acid, may be tanned with formaldehyde. For each 100 parts of pelt, use 1 part of formaldehyde, that is, about 2½ parts of commercial formaldehyde in a convenient quantity of water, so that the skins can be immersed in the

solution. The skins are left in from 24 to 48 hours, then neutralized by washing in a bath containing sodium carbonate or borax, or a mixture of ammonium sulphate and sodium carbonate; washed in clean water, drained, and fat-liquored with a solution of 3 parts of soft soap in 60 parts of water, then dried and finished.

*Tanning with a mineral and vegetable tannage.*—The formula for this process of tanning is: aluminum sulphate, 5 lb.; common salt, 5 lb.; gambier, 2 lb.; rye flour, 13 oz.; and water, 10 gallons.

Dissolve the sulphate and salt in a little water; also dissolve the gambier by boiling in a little water. Mix the two solutions. The rye flour is made into a smooth paste with a little warm water, and the alum, salt, and gambier solution are added to the paste, the whole being thoroughly stirred to a thin paste-like mixture. This is applied to the flesh side of the skin with a brush, applying a coating about $\frac{1}{8}$ inch thick, afterwards folding the skins into cushions. The goods, after lying some time in the wet condition, are hung up and dried. It is said of this method of tanning that it gives soft and flexible skins, and the tannage is more durable than the alum tannage.

Sheep pelts can also be tanned by a chrome process by the methods described for furs and hair skins.

*Tanning with gambier.*—To tan woolskins with gambier, first tan them with alum and salt, and then put them into weak gambier liquor. The dry powdered alum and salt should be rubbed into the wet skins, two applications being required. The skins are then tanned with the gambier. For 50 skins the addition of 1 lb. of picric acid to the gambier liquor colors the wool a light yellow. The liquor should be rather weak at the start, and strengthened until the skins are tanned through. Alum-tanned skins can be colored a light yellow by immersing them in a solution of picric acid previous to tanning. After they have been scoured and rinsed, put the skins into a bath of 15 pails of warm water, to which has been added 4 oz. of picric acid dissolved in a little water and

6 oz. of sulphuric acid. The skins should be moved backward and forward for 15 minutes, then rinsed in water and tanned with alum and salt.

*Tanning with alum, salt and hemlock extract.*—Skins tanned by this process, and then scoured and passed through a weak bath of sulphuric acid, are made a golden-brown color. The pelts are soaked and scoured before tanning, special care being taken to get the wool clean. The tanning liquor is made of alum, salt and extract of hemlock bark which is weak at the start and strengthened as the tanning proceeds. Some potash soap should be added to the stronger liquor to help turn the wool and give the skins a velvety feel. After the pelts are well tanned they should be drained off and oiled on the flesh with a good quality of mineral oil, applied warm, and then hung up to dry. When dry, they are scoured with a strong solution of potash soap and soda ash. Both wool and flesh are scoured. The scouring suds are thoroughly rubbed into the wool and washed out again, the operation being repeated two or three times. This scouring darkens the wool. A weak solution of sulphuric acid, made from ½ lb. of acid in 10 gallons of water, is thrown onto the wool after it has been rinsed free from suds, and should be rubbed thoroughly into all parts of the wool. It changes the color of the wool to a light golden brown. The wool is next given a good blowing out with water from a hose and made as clean as possible, and the skins are then hung up to dry. Finishing consists of dampening, arm-crutching, buffing on the flesh side, and beating the wool soft and clean.

*Coloring.*—Woolskins and shearlings may be colored any shade of color by the application of basic or acid dyes. Basic colors, however, are used chiefly on the cheaper grades of skins and where no particular demands are made for fastness to rubbing and washing. Where fastness is essential, acid dyestuffs should be used; and in order that the skins may withstand the high temperature required for dyeing, they should be first subjected to a chrome tannage.

When acid dyestuffs are used, the process of coloring is as

follows: The skins are either tanned or re-tanned with one-bath chrome liquor. The temperature of the solution should be 70° F., and the whole of the flesh side should be exposed to the liquor. After 2 or 3 hours the skins are lifted out and a solution of sodium carbonate is added to the chrome liquor; the skins are put back and left in from 12 to 24 hours, even longer if thick and heavy. They are then rinsed. Any chrome liquor may be used, but in any case it is advantageous to add ½ lb. of formaldehyde to 10 gallons of liquor, which increases the resistance of the leather to heat.

To increase the affinity of the wool for the dye, the skins are subjected to a chlorinating process. To do this, the skins are immersed for 15 minutes in a cold bath containing 1 lb. of hydrochloric acid in 10 gallons of water. Then, without rinsing, they are put into a bath of cold water to which is gradually added, in four portions, a clear solution of 8 to 14 oz. of chloride of lime for each 10 gallons of liquor. After one hour in this bath, the skins are re-entered into the first bath, in which they are worked another 15 minutes. They are then rinsed in lukewarm water containing 3 to 5 oz. of sodium thiosulphate or bisulphite in 10 gallons of liquor, to remove the last trace of chlorine. After pressing or hydro-extracting, the skins are ready for dyeing.

*Dyeing.*—Black is dyed with naphthylamine black S, ESN, SS2B, naphthylamine blue black B, BD, naphthol black, also azo merino black B. Of these dyestuffs, 4 to 6 oz., calculated on the dry weight of the skins, are required to produce a deep black. Where basic colors are used, it is advantageous to treat the skins with acid and chloride of lime as described for acid dyes, then rinse and pass through a solution of tanning material—say, 2 oz. of sumac, hemlock, cutch, or quebracho extract, dissolved in water—immersing for half an hour, then wash and color. One ounce of basic dye is generally sufficient for two skins. To the solution of dye, ½ oz. of acetic acid and 4 oz. of Glauber's salt should be added. The temperature of the dye-bath should be from 100 to 110° F. Good, fast shades of color are also produced by immersing the

skins in a bath of sumac, hemlock, or quebracho for a half-hour, next immersing in a solution of titanium-potassium oxalate, then coloring with basic dye, 2 oz. of the tanning extract and 1 oz. of the titanium salt being sufficient for two skins.

To get a slight gloss on the wool, the skins should be passed through a weak solution of soap and oil, then dried and finished. Six gallons of stock soap and oil mixture are made by boiling 6 lb. of soap and 18 lb. of oil and making up to 6 gallons, $\frac{1}{8}$ pint of this mixture for two skins being added to 10 gallons of hot water, and the skins, flesh-to-flesh, are passed through the bath, then dried, softened, and finished.

In addition to the method described for dyeing woolskins black with acid dyestuffs, a good black can be secured by dyeing with logwood, fustic, and potassium dichromate. The skins should be scoured and rinsed well before they are colored. The first bath consists of $\frac{1}{2}$ lb. of the dichromate dissolved and added to 10 gallons of water at 100° F. The skins are doubled, flesh side in, and immersed in the solution; then they are removed and drained.

The second bath consists of strong logwood liquor to which some fustic extract and some ammonia have been added; $1\frac{1}{2}$ lb. of logwood crystals, 4 oz. of fustic, and 1 pint of liquid ammonia being used for 10 gallons of liquor. The temperature of this bath should be 120° F., and the skins should remain in it until every part has been colored; they should then be drained and immersed in a bath of 1 lb. of dichromate in 10 gallons of water. After the skins have been passed through the liquor they should be drained, and the wool should receive an application of seal oil, well rubbed in, drained, washed, dried, and finished.

Another process of dyeing woolskins black is as follows: For a dozen skins, a bath is prepared of 80 gallons of water, 20 lb. of logwood extract, $3\frac{1}{2}$ lb. of fustic extract, and 2 lb. of verdigris or copper acetate. This bath is heated to 110° F., and the skins allowed to remain in it for 3 or 4 hours, the same temperature being maintained during the process; $2\frac{1}{2}$ quarts of acetate of iron is then added to the bath, and

the skins left in the liquor until they are dyed black. This usually requires an immersion of 30 or 40 hours, during which time the skins are occasionally stirred.

The skins are then drained and allowed to oxidize for at least 12 hours; they are then washed in warm water and scoured with a solution of soft soap and ammonium carbonate, washed and drained. They are finally re-tanned with alum and salt, and stretched in frames to dry.

A good shade of tan is obtained by putting the skins, after washing from the tannage, into a sumac bath for a half-hour, 2 oz. of sumac being used for each pair of skins; next allow the skins to drain, and then immerse them in a bath of titanium salt, 1 oz. for two skins. This produces a yellowish-brown color. Any shade of color can be obtained on skins treated as described by using 1 oz. of basic dye, ½ oz. of acetic acid, and 4 oz. of Glauber's salt for every two skins. Colors produced by acid dyes are faster to rubbing and washing than colors obtained by using basic dyestuffs.

**Tanning furs and hair skins.**—M. C. Lamb (previously mentioned) has described a method of tanning fur skins, which has advantages over the common alum tannage; the process is partly mineral and partly vegetable, and skins tanned with it are soft and durable: The process consists of applying to the flesh side of the skins a mixture made of alum, salt, gambier, and glycerine. The formula is: aluminum sulphate, 5 lb.; common salt, 5 lb.; gambier, 2 lb.; rye flour, 13 oz.; and water, 10 gallons. Dissolve the sulphate and salt in a small quantity of water, and boil the gambier until it is dissolved, then mix the two solutions. The rye flour is made into a thin paste with lukewarm water; the oil or glycerine is added to the flour paste; and finally the alum, salt, and gambier solution is added, and the whole is thoroughly mixed to a thin paste-like mixture. To this, ½ to 1 lb. of glycerine or the same quantity of olive oil is added to make the skins softer. This addition is particularly essential when the skins are naturally of hard texture and do not possess much natural grease.

The paste is then applied about ⅛ inch thick with a brush to

the flesh side of the skin. The skins are then folded or placed flesh-to-flesh, and after lying for some time, and perhaps receiving another application of the paste, are hung up to dry.

Another excellent alum process is described in the *Shoe and Leather Reporter:* For the tanning liquor, dissolve 5 lb. of alum and 6 lb. of salt in 12 gallons of hot water. If the skins are greasy, the addition of ½ lb. of borax to the liquor is recommended. The liquor should be warmed to 95° F., and the skins occasionally moved to make the tanning uniform. After 24 hours the skins should be removed and coated on the flesh side with a paste made of alum, salt, and flour. The following formula makes sufficient paste for 100 lb. of skins: alum, 4 lb.; salt, 3 lb.; flour, 4 lb.; egg-yolk, 1 lb.; and olive oil, 1 lb.

The flour is made into a paste with water; the alum and salt are dissolved separately in boiling water. When the solution is cool, the flour paste is stirred into it, and after the mixture has been thoroughly stirred, the egg-yolk and olive oil are added. The primary object of the flour is to obtain a mixture in a semi-pasty form so that it will adhere to the skins. If the above quantity is not sufficient to make the mixture sufficiently pasty, either less water should be used in dissolving the alum and salt, or more flour should be used in making the paste. The flour also helps to give fuller leather. The egg-yolk and olive oil give softness to the skins. For the finer furs, a small quantity of egg-yolk is quite essential. Where economy is desired, olive oil may be substituted for the egg-yolk, with similar results. Instead of giving a preliminary treatment in alum liquors, the tannage may consist of the application of the paste only. The skins should be allowed to lie for some time with alum paste adhering to them, which makes the tannage more complete and permanent.

If it is desired to dye the furs with acid colors, it is necessary to wash them after they have been dried and worked soft, and re-tan them with chrome liquor.

Soft, white, and well-tanned skins are obtained by tanning

with a paste of alum, salt, and oatmeal. Heat 1 gallon of water and stir into it 1 lb. of pulverized alum, then add half as much salt as alum and boil until these are dissolved. While the solution is boiling, add $\frac{1}{2}$ lb. of rolled oats, boil 15 minutes, and then set the paste aside to cool. By adding a few ounces of gambier to the liquor and boiling again, the skins treated with it will be given a light yellow color.

The cleaned and softened skins are spread out on a table, flesh side up, and a heavy coat of the prepared paste is applied with a brush. This painting is repeated every day until the skins are tanned, which takes from 2 to 6 days, according to their thickness. When tanned, the skins are hung up to dry, then stretched and worked out soft and white. The fur is cleaned with dry, hot sawdust, and the flesh made perfectly clean and smooth by buffing on an emery wheel.

When a large number of skins are to be cleaned a drum or cage is used; on a small scale they may be tramped on or pounded in a barrel or tub, or cleaned by brushing the hot sawdust into the fur with the hands, and then beating it out with a supple stick. Hardwood sawdust is better than that from pine.

**Washing greasy skins.**—Skins containing a good deal of natural grease should be washed in a warm solution of sal soda and then scraped over the beam, and the grease forced out of them. Dogskins should be fleshed dry, that is, before they are soaked, as in this condition they flesh more easily than after soaking.

To wash greasy skins, prepare a warm solution of sal soda by dissolving the salt in water heated to 90° F. Dip the skins into this solution long enough to get them wet and hot, then put them upon the beam and go over them with a flesher or dull knife, bearing down hard and forcing the grease out. The dipping and scraping should be repeated until the skins are free from grease. They are then rinsed, drained and tanned.

**Oil process.**—Furs can be tanned satisfactorily with seal oil. The goods are first freed from superfluous moisture by

draining or hydro-extracting, and are then rubbed over on the flesh with a good quality of seal oil. The skins are folded into cushions, flesh side innermost, and placed in a large wooden tub. Impregnation of the skins with the oil is facilitated by a workman treading the goods with his bare feet, thoroughly trampling the skins down and thereby working the oil into them. The goods, after being worked in this way, are left for several hours, and then another application is made, and the process repeated. When the goods have become thoroughly impregnated with the oil, they are laid in a pile. Care must be taken that they do not reach a temperature higher than 100 to 104° F. A tannage effected in this way is somewhat similar to that used in the dressing of chamois leather, and depends on the decomposition of the oil and the production of aldehydes. When thoroughly tanned, the goods are rinsed through a weak alkaline solution for the purpose of removing undecomposed oil and grease, and then are subsequently dried. This is the so-called "furriers' dress process." To aid in this method of oil tannage the skins are sometimes tumbled in small drums until the heat of reaction is produced.

**Oiling alum-tanned skins.**—Skins that have been tanned with an alum paste containing oil or egg-yolk do not require further oiling to make them soft, but where no oil is used in the tanning paste it is advisable to apply a coat of oil after the skins have been tanned and dressed down, or partly dried. Sulphonated neat's foot oil is satisfactory; so is a good mineral oil. Mop the oil over the flesh of the skins, let them lie on a pile for a day or two, then hang up to dry. Working out and cleaning in sawdust completes the work.

A solution of soap, also one of stearine, is recommended for alum-tanned skins. The use of either of these fixes the tannage and makes it more permanent.

**Deodorizing furs and rugs.**—The following solution is useful for removing objectionable odor from furs, rugs, etc. Put 8 lb. of tanner's soap, or any other good bar soap, chipped fine, into 4 gallons of water. Add 7 lb. of sal soda. Boil until the soap and soda are dissolved, and while the solu-

tion is hot, add $1\frac{1}{2}$ oz. of borax and 1 oz. of oil of sassafras. Put the solution aside to cool, and it is then ready for use. This liquor can be used on skunk skins, but they should not be rinsed out before tanning. After the skins have been dried and cleaned it will be found that the bad odor has disappeared.

*Cleaning furs.*—Dark furs may be cleaned with bran or with warm cedar, mahogany, or other hardwood sawdust. Beat the skin gently with a stick and brush it until it is free from dust, then lay it on a table with the hair side up and rub the hot sawdust or bran through the fur. Use plenty of sawdust and rub vigorously. After this, beat and brush the fur until it is free from sawdust or bran and is clean and fluffy. White furs can be cleaned in the same manner except that white cornmeal is used instead of sawdust. The cornmeal should be used warm. Soiled places may be cleaned by rubbing with cube magnesia. Allow the powder to remain in the fur for a day, then brush it out thoroughly.

Professionals clean fur garments, muffs, etc., by dipping into gasoline until they are clean. They are then dried and the gloss is produced by passing bread crust lightly with the grain of the fur.

*Liming.*—Where the skins are subjected to a liming process before they are tanned, they work out very soft and elastic. In this case, however, liming is a process different from liming for leather. In the latter process the hair is loosened, but in liming fur skins and sheep pelts the hair or wool is not affected. The process is the same as that described under woolskins.

**Chrome-tanned furs and woolskins.**—In order that the tannage of furs and woolskins may be permanent, that is, not affected by moisture, and the leather made as durable as possible, it is advisable to tan with one-bath chrome liquor. A commercial liquor may be used or any good one-bath chrome liquor employed. Where furs are to be dyed in hot dye-liquors, $\frac{1}{2}$ lb. of formaldehyde should be added to 10 gallons of chrome liquor to increase the resistance of the skins to heat. The skins are placed in this liquor and paddled for two

hours or drummed one hour. At the end of that time, 3 lb. of washing soda in solution is added to the liquor and the process is continued an hour or two longer if in the drum; or the skins are left in the liquor from 12 to 24 hours if in a paddle. They are then drained several hours, and if not to be dyed, they are neutralized by being washed in water containing 2 or 3 per cent of borax, reckoned on the wet weight of the skins, using sufficient water to work the furs nicely. After this has been done, the skins are well washed with clean water.

After the furs have been washed and drained, a fat-liquor is applied to the flesh side. Any light chrome leather fat-liquor may be used, and applied in the drum or brushed on the skins. Instead of applying the liquor in a drum, a hot solution of sulphonated oil and flour, or of the oil alone, or a mixture of egg-yolk and flour, may be applied to the flesh side, the skins folded and left until the next day and then hung up to dry. An excellent method of chrome-tanning furs, hair skins, and sheep pelts is carried out in the following manner: The skins are soaked, fleshed, and washed clean: they are next plumped with caustic soda and calcium chloride in the manner previously described, then neutralized with lactic or formic acid and tanned.

The first step of the process consists of a solution of 2½ lb. of alum and 1 or 2 lb. of salt in 5 gallons of boiling water. When the solution has cooled to 75° F. the skins are immersed in it and stirred about for an hour, then allowed to remain in the solution from 12 to 24 hours. A few pounds of salt and 3 or 4 gallons of chrome liquor are added to each 100 gallons of water. A smaller bath may be used by keeping the same proportions. As the skins absorb the tanning material, more concentrated chrome liquor should be added, and the goods are left in the solution until they are tanned through. When the green color has penetrated throughout the thickest skins, a few ounces of bicarbonate of soda should be added to the liquor, and the skins left in a day longer. They are next washed in borax water, then in clean water, drained, fat-liquored, and dried, or dyed immediately after the tannage

is completed. A paste made of sod oil and flour forms a suitable fat-liquor for this tannage.

**Tanning hair skins with alum and gambier.**—For the tanning of hair skins for rugs, robes, and mittens, a tannage of alum and salt, and either gambier or quebracho is satisfactory. The skins are soaked, fleshed, washed, and spread on a table and a mixture of pulverized alum and fine salt is rubbed into the flesh side with a brush until all spots are covered. Each skin is then folded down the center, or rolled up and left in that condition for 24 hours. A second application of alum and salt is again brushed in and the skins are left in piles a day or two longer. This treatment sets the hair so that it will not slip during the subsequent treatments. The skins may be dried and finished without further tanning, but a treatment with gambier or quebracho liquor makes a more permanent tannage and a more durable leather.

A fairly strong liquor is made by boiling either gambier or quebracho extract, and when it is cold, the skins are immersed in it and left for several days, according to their thickness. The liquor should be rather weak at first and strengthened as the skins absorb the tan.

The goods are then washed, drained, and either hung up or stretched in frames to dry. When the excess of moisture has evaporated, warm oil should be applied to the flesh and brushed in. Any good leather oil may be used, sulphonated oil being preferable. When thoroughly dry, the skins are beaten and brushed until the leather is soft and the hair clean.

**Cleaning white fur rugs.**—These and wool rugs may be cleaned by the application of a paste of powdered chalk and water, prepared by mixing the two into a thin paste and then rubbing the latter thoroughly into the fur or wool and allowing it to dry. When dry, the paste is thoroughly brushed out with a stiff brush, and, to finish, a finer brush is used to remove every particle of chalk. This treatment takes away all dirt and grease and causes the goods to be clean, soft, and fluffy.

*Bleaching skins with the hair on.*—Goatskins, sheepskins, and lambskins intended for rugs, robes, etc., can be bleached

by using a solution prepared in the following manner: 4½ lb. of chloride of lime is added to 21 quarts of water, the solution being stirred for some time. It is then allowed to stand until it has settled, when the clear liquor is drawn off into a solution of 5½ lb. of Glauber's salt in 10½ quarts of water. A precipitation results which leaves sodium hypochlorite in solution. The clear liquor, which should be quite free from lime, is next drawn off, and the skins are immersed therein until they are bleached, which takes about two days. They should next be rinsed in water and then washed in weak suds of white soap to give the necessary soft feel. Prior to bleaching, the skins should be washed with warm suds and rinsed. Alum-tanned skins may require a re-tannage after bleaching. This is done by rubbing powdered alum and salt, or a paste of the same, on the flesh side before hanging the skins up to dry.

**Dyeing China goatskins black.**—These skins, tanned and made up into rugs, may be dyed black in the following manner, the quantities being for 60 rugs, which is equivalent to 120 skins: In a vat of about 360 gallons capacity, make up a bath of 24 lb. of concentrated ammonia and 36 lb. of sal soda, previously dissolved. When these have been added to the water, heat to 95° F., and immerse the rugs for 2 hours stirring them occasionally, then pull and let them drain thoroughly.

Dissolve 50 lb. of dark turmeric, and 45 lb. of logwood extract, and add all to the bath. Enter the rugs and let them remain in the liquor until they rise to the surface. Then haul and add 25 lb. more of logwood extract, 10 lb. of sumac, 10 lb. of bluestone (copper sulphate), 5 lb. of fustic extract, and 60 lb. of acetate of iron. Immerse the rugs for 18 hours; then draw and expose them to the air for 12 hours. Heat the liquor again to 95° F. and put the skins back for 12 hours longer. Draw them out of the liquor; hang in the air for a time, and then wash. The washing should be done thoroughly with plenty of clean running water until all dirt and superfluous dyestuff has been removed; the rugs should then

be wrung and tacked out to dry. When almost dry, put them into a drum, with a mixture of sea sand and mahogany dust, and run 4 hours, after which they should be put into an open slat wheel or cage and run for 2 hours to clean out the sand and dust. The latter process, if carried out properly, will be found to give an added brilliancy to the fur, which cannot be obtained in any other way.

**Dyeing furs with acid colors:** *Re-tannage.*—The use of acid dyestuffs is preferable to basic colors in the dyeing of furs, hair skins, rugs, etc., on account of their greater fastness to washing and rubbing. The skins can be dyed black or fancy colors with acid dyes, but in order that they may stand the high temperature of the dye-bath without injury, it is necessary to re-tan them with a chrome tannage. Such a tannage not only increases the resistance of the furs to the hot dye-bath, but also makes them more waterproof and more durable. Alum-tanned skins in particular require such tannage.

The skins should be placed in the chrome liquor in such a manner that the flesh side is fully exposed. If thrown in loosely, they should be stirred frequently and kept opened out. It is well to suspend large skins in the bath so that the flesh will get the full benefit of the re-tannage.

*Chlorinating the furs.*—To impart greater affinity for the dyestuff to the skins, it is necessary to treat them with chloride of lime in the same manner as described under woolskins.

*Dyeing.*—For 100 lb. of furs, 10 to 20 lb. of Glauber's salt, 2 to 5 lb. of acetic acid, and the dyestuff in solution are added to water heated to 120° F., and the furs are placed in this bath. The temperature of the bath is gradually raised by steam to 165° F.; and after a half-hour from 6 to 8 lb. of sodium bisulphate is added in 2 or 3 portions, and the skins worked at the same temperature for 30 minutes; they are then rinsed thoroughly and drained or hydro-extracted.

After the furs have been rinsed, it is advisable to pass them through a solution of soap and oil, which imparts a soft feel to the hair. The solution is made of 1 lb. of olive oil soap, 2 or 3 oz. of olive oil, and 1 or 2 oz. of ammonia in 10 gal-

lons of water. The furs are worked in this solution for 15 minutes or longer, and are then drained or hydro-extracted and dried without rinsing. When dry, they are worked out soft and cleaned.

A rich black is obtained by dyeing the furs in the manner that has been described with from 4 to 6 per cent, calculated on the dry weight of the skins, of the following dyes: naphthylamine black S, ESN, SS2B; napthylamine blue black B, BD; naphthol black B, SG; and azo merino black B. As shading dyestuffs for black, the following are used: Indian yellow FF; tropaeoline OO; acid yellow AT; fast yellow S; and orange 11, extra.

For blue shades: cyanole FF extra; tetra cyanole V; indigo blue N; azo wood blue SE; naphthol blue R; solid blue R; and formyl blue B.

For shades of yellow and orange: fast yellow S; acid yellow AT; fast acid yellow 3 G, TL; Indian yellow G, R; naphthol yellow S; tropaeoline GO, OO; and orange GG, extra II, IV, R.

For red, claret, etc.: lanafuchsine SG; SB; 6 B; azo orseible BB; Bordeaux BL; and brilliant orseible C.

For violet: azo wood violet, 7 R; 4 B; acid violet 4 R S; and 6 B S.

For green: naphthol green B; fast acid green B N; and cyanole green B.

For brown: Combinations of various yellows, orange, green, blue, etc., are used.

For light shades, about 0.2 to 0.5 per cent dyestuff is used, and for full shades up to 3 per cent dyestuff, calculated on the weight of the dry skins.

For gray: silver gray N, which is dyed with the addition of ½ to 1 per cent alum without any other addition.

**Dyeing with chromate colors.**—This method of dyeing is valuable in all cases where the demands for fastness are exacting. Most fancy shades can be produced with chromate colors, but for black it is necessary to use acid colors.

The preparation of the skins is the same as in dyeing with

acid colors, except that the treatment with chloride of lime may be omitted, as the hair absorbs the chromate dyestuffs well enough without this treatment. For particularly full shades, however, the treatment with chloride of lime is useful also. The dyeing is carried out as follows:

The dyestuff is dissolved in the regular manner, and half as much sodium dichromate as dye is dissolved in a separate vessel, and the two solutions are mixed in the dye-bath. The temperature of the liquor at the start should be 170° F., and the furs are dyed at this temperature for 1 to 2 hours. An addition of 1 to 3 per cent acetic acid is then made, and the skins are worked for another half-hour, rinsed and hydro-extracted. To ensure good leveling on felted wool it is advisable to use 3 or 4 per cent monopole soap. Many shades of yellow, brown, green, blue, red, gray, etc., are obtained by using the anthracene chromate dyes alone or in various combinations, according to the shade desired.

Acid and chromate colors are dissolved by pouring boiling water over them, and boiling if necessary. The solution should then be passed through cheese-cloth or a fine sieve, and any particles remaining undissolved are brought into solution by pouring more boiling water over them.

**Dyeing furs black with furrol dyes:** *Preparation of the skins.*—Fur skins that are to be dyed are first subjected to the "killing" process, which cleans and de-greases the hair; this is done in various ways as follows:

1. *Drum killing with soda solution.*—The skins are soaked for 3 hours in a cold solution of 1 lb. of soda ash in 10 gallons of water. They are then washed, feebly acidified with acetic acid, and rinsed again.

2. *Drum killing with milk of lime.*—One pound of freshly slaked lime is mixed with 10 gallons of water. The skins are treated in this cold liquor, then acidified with acetic acid, and rinsed.

3. *Drum killing with caustic soda lye.*—A liquor is prepared, according to the nature of the skin, with 6 oz. to $2\frac{1}{2}$ lb. of caustic soda lye of 77° Tw. for 10 gallons of water,

and the skins, the flesh side of which has been spread with starch paste, are treated therein at ordinary temperature for about 3 hours. Furs with very hard hairs, such as raccoon skins, are left somewhat longer in the caustic soda lye. They are then feebly acidified with acetic acid and rinsed.

4. *Brush killing with caustic soda lye.*—According to the quality of the skins, prepare a caustic soda lye solution of 2 to 12° Tw., and brush it onto the hairs. For some special kinds of fur, foxskin, for instance, a stronger lye is applied on the belly portion and a weaker one on the back. The furs in this state are left lying bundled, fur-to-fur, for 3 to 8 hours, when they are dried, brushed, or cleaned. The skins are next given a drum killing as directed under 1 and 3.

*Mordanting the furs.*—The dyeing operation consists of two processes, namely, the mordanting and the dyeing proper. Mordanting of the hair is required to effect a quicker and fuller absorption of the coloring matter in the dye-bath, and is done by immersing the previously cleaned and killed skins in the solution of mordant, the time required depending upon the nature of the hair and the temperature of the bath. The following solutions are used as mordants:

| *Solution* | *Quantity of salt, ounces* | *Water gallons* |
|---|---|---|
| Alum | 16 | 10 |
| Copper sulphate | 8 | 10 |
| Sodium dichromate | 4 | 10 |
| Chrome-alum | 16 | 10 |
| Iron sulphate | 4 | 10 |

These mordants are used without further additions, or else with the addition of 3 oz. of tartar or 2 to 3 oz. of 30 per cent acetic acid. The mordanting solution is best applied at a temperature of 68 to 77° F. For less delicate furs, the solutions may be heated to 95° F. to allow of more rapid working.

The duration of the mordanting depends on the quality of the skins and the results desired; when working at a temperature of 68 to 77° F., 6 to 12 hours will be sufficient as a rule, and if a higher temperature is maintained the time may be reduced. The skins are then rinsed, and if an acid

mordanting bath has been used, some soda should be added to the rinsing bath, the goods being once more well rinsed. They are then dyed.

*Dyeing black.*—Black is dyed by brushing in the following: three ounces of furrol S and $\frac{1}{3}$ oz. of phenylene diamine powder are dissolved in 1 gallon of water, and immediately before use, add 3 lb. of hydrogen peroxide. This solution is brushed on the skins three times, allowing them to dry after each application.

*Raccoon (imitation skunk).*—These skins are brush-killed with caustic soda lye of 40° Tw. or drum-killed with 1 lb. caustic soda lye of 77° Tw. per 10 gallons water.

The mordant solution consists of $1\frac{1}{2}$ oz. of copper sulphate, $4\frac{1}{2}$ oz. of iron sulphate, and 4 oz. of tartar in 11 gallons of water.

Dyeing is done with $4\frac{1}{2}$ oz. of furrol gray R and 3 oz. of ammonia. The black dye is brushed on in solution prepared as above directed.

*Lambskins.*—These are drum-killed with 1 lb. of lime in 10 gallons of water; and mordanted with 8 oz. of copper sulphate in 10 gallons of water.

Dyeing black is then done with $4\frac{1}{2}$ oz. of furrol S and $\frac{3}{4}$ oz. of phenylene diamine powder, and 12 to 15 times the weight of the dyestuff of hydrogen peroxide is added to all the other ingredients.

*Red-haired fox.*—This is dyed black by being first brush-killed with caustic soda lye of 2 to 3° Tw., or drum-killed with 12 oz. of lye of 77° Tw. in 10 gallons of water.

The mordant solution is 1 lb. of chrome alum and 3 oz. of tartar per 10 gallons of water.

The dyeing is done with 10 oz. of furrol gray R, $\frac{1}{4}$ oz. of phenylene diamine powder and 20 oz. of ammonia, and hydrogen peroxide, 12 to 15 times the weight of the dyestuff. The black dye is brushed on the skins three times, allowing them to dry after each application. This dyes the furs in imitation Alaska.

Red-haired fox is also dyed black in the following man-

ner: The furs are brush-killed with caustic soda lye of 2 to 3° Tw., or drum-killed with 12 oz. of caustic soda lye of 77° Tw. in 10 gallons of water. The mordant is 7 oz. of copper sulphate and 3 oz. of tartar in 10 gallons of water.

The dyeing is done with 4½ oz. of furrol S and ¾ oz. of phenylene diamine powder and hydrogen peroxide 12 to 15 times the weight of the dyestuff, per 10 gallons of water.

*Seal rabbit* (*English imitation of seal*).—These furs are drum-killed with 1 lb. of lime in 10 gallons of water. The mordant is 8 oz. of copper sulphate, and 3 oz. of tartar in 10 gallons of water.

The first dye-bath consists of 3 oz. of furrol yellow-brown G, 3 oz. of ammonium chloride, and ⅓ oz. of ammonia. The second bath consists of 1⅓ oz. of furrol S, 7 grains of phenylene diamine powder, 3 oz. of ammonia, and hydrogen peroxide 12 to 15 times the quantity of dye, in 10 gallons of water.

Black seal rabbit is dyed as follows: Drum-killed with 1 lb. of lime per 10 gallons of water; mordanted with 6 oz. of copper sulphate and 3 oz. of tartar in 10 gallons of water; dyeing with 5 oz. of furrol S and 1¼ oz. of phenylene diamine powder in 10 gallons of water, with hydrogen peroxide 12 to 15 times the quantity of dyestuff.

**Tanning for robes, coats, etc.**—Hides of horses and cattle that are to be tanned with the hair on them and used in the manufacture of coats and robes should be soaked in fresh water before they are tanned, in order to soften and rid them of dirt, blood, and other undesirable substances. They should be soaked long enough to become thoroughly softened, the length of time ranging from 12 to 24 hours.

Dry hides are more difficult to soften than salted hides. Borax, salt, and formic acid are all useful in softening such hides. When borax is used, from 5 to 6 lb. dissolved in hot water, is mixed in 1000 gallons of water. The effectiveness of this soak is increased by raising the temperature to 90° F. The hides may be left in the soak for 12 hours, then worked on the beam or milled in a drum in a solution of borax and water; or they may be softened in a hide mill. After the

milling, they usually require further soaking to bring them to the proper condition.

When a salt soak is used, enough salt is added to the water to make it decidedly salty. The hides may be left in the brine from 12 to 24 hours, next drummed in salt water for 30 minutes, and then re-soaked until soft enough to be tanned.

Formic acid added to the soak water hastens the softening, and, being antiseptic, prevents decay of the hides; a suitable strength is 1 or 2 lb. in 100 gallons of water. After soaking is completed, the hides should be fleshed and all flesh and lumps of fat removed before they are tanned.

*Alum and salt process.*—In applying this process, the hides, after they have been fleshed, are placed in a fairly strong solution of alum and salt, care being taken to expose all parts of the flesh side to the liquor, so that the hair roots may become firmly set and hair-slipping avoided. The penetration of the liquor is hastened by warming to 85° F. before the hides are entered. The hides should be given plenty of room in the liquor so that they can be handled occasionally and their positions changed. It is good practice to hang them on sticks and suspend them in the liquor. Hides may be well struck through with a liquor made up of 6 lb. of alum and 12 lb. of salt for every 100 lb. to be tanned. They should be left in the tanning liquor until they become permeated with it, the length of time required depending upon their thickness and the strength of the liquor. They should then be soaked for a half-hour in cold water and hung up to dry. When about two-thirds dry they should be laid in piles for a few days to become uniformly soft and moist before they are dressed down. While the hides are in piles it is advisable to watch and handle them occasionally, especially in warm weather, to prevent heating, which causes more or less damage according to the degree of heat developed.

The cutting down to a light substance is done by hand, work which requires considerable skill and judgment in order that the hide may be smooth, of even thickness, and free from holes. After the hides have been dressed down it is

advisable to re-tan them. They may be returned to the alum and salt liquor; or they may be re-tanned with alum and salt in a drum; and they may be re-tanned with chrome liquor. Re-tanning is also sometimes done with gambier or quebracho. One method of re-tanning is as follows: The hides are put in a drum with 6 lb. of aluminum sulphate and 8 lb. of salt in 39 gallons of water for each 100 lb. of hides. The goods are drummed in this for an hour. A solution of 10 lb. of sodium thiosulphate in 5 gallons of water is then poured into the mill and drumming is continued for 30 minutes, thus securing fixation of the tanning material on the fibers of the hides. The goods are then rinsed in water and hung up. When nearly dry, they are stuffed with oil or grease, dried thoroughly, then worked out soft and clean.

By re-tannage with gambier and salt the unpleasant features of alum-tanned stock are prevented, and the hides are made soft and strong. The liquor may be applied in a drum or in a vat, the process being carried along until the liquor has thoroughly permeated the hides. They are then placed in piles for 48 hours, drained well, and hung up to dry.

*Softening and cleaning the stock.*—For imparting softness to the goods, oils of various kinds may be used, also combinations of tallow, soap, and oil. Mineral oils are also satisfactory. A heavy coat of oil should be applied to the flesh side, and the goods then allowed to dry slowly and kept in the dry condition some time before they are finished. The longer they are kept in the dry condition the softer they will be when finally finished.

Softening and cleaning of the hides is best accomplished in revolving wheels or drums. The oil, grease, and dirt are taken up by dry sawdust in a closed drum; or in an open or latticed drum, the sawdust, carrying the oil and grease with it, is thus cleaned out of the stock. The cleaning process ought to be repeated two or three times to get the goods perfectly clean and soft. Some yellow ocher added to the sawdust gives the flesh side a desirable yellow color.

Dyeing may be done with acid or furrol dyestuffs in the same manner as furs, which has been described.

# CHAPTER XVII

## VEGETABLE TANNING MATERIALS

In the manufacture of leather, advantage is taken of the fact that certain substances have the property of combining with hide substance and in so doing form a new compound not susceptible to decomposition. The various processes already described plainly indicate that fact, so in this chapter we will consider those organic substances derived from vegetable matter, and which contain tannin as their active constituent.

The chemistry of the tannins has not been exhaustively studied, so it is impossible to go deeply into the scientific side of the problem. Suffice it to say that the tannins are divided into two groups, one class being such substances as contain pyrogallol tannin and the other catechol tannin.

It does not follow, however, that two substances containing the same kind of tannin will produce the same kind of leather; in fact, the various tanning materials differ widely from each other in their chemical and physical constitution, but they all have the common property of precipitating gelatine from solution and of combining with hide substance. Not only do the tannins present combine with the animal tissues to form leather, but the non-tannins have a decided effect upon the appearance and physical properties of the finished product.

Those tanning materials which give a bloom to the leather are usually of the pyrogallol class, while those producing no bloom are of the catechol group.

Many tanning materials contain certain quantities of insoluble or partly soluble tannins which are known as "reds." These are more pronounced in acid liquors, especially sulphuric, and many are completely soluble in alkaline liquors. These reds are taken up to a greater or less degree during the tanning process, and in the case of sole or heavy leather,

have a decidedly beneficial action, causing firmness in the stock.

In the production of commercial tannin solution, the bark, leaves, twigs, or wood form a great variety of vegetable substances. The material is first reduced to the form of chips and then lixiviated with water. This lixiviation formerly was carried out at the tannery by leaching the bark in a series of tanks. As the supply of tannin material near at hand became scarce, it was found necessary to go farther away for it. Transportation is a considerable item, especially as the tannin content in most materials is comparatively small. As a result, manufacturers have found it more economical to leach the bark or wood nearer the source and to furnish the concentrated extract to the tanner. Thus the manufacture of tanning extracts is a new industry which has sprung into existence through force of necessity. These extracts have the advantage of being in a concentrated condition and are ready for use by simple dilution. Thus also a weak liquor can be quickly strengthened by adding extract, while by the old process it would have to be returned to the leach.

Since the advent of concentrated extracts, the old-time leach-house has become a thing of the past, and although many tanners still leach certain barks, they all depend upon extracts for bringing up the strength of the liquor and also use them to hasten the tannage. In the production of ordinary tanning liquor or concentrated extract the preliminary operations are the same, and it will therefore save space to give a description of the two processes at the same time, carrying, of course, the thin liquors through the evaporation in order to make the commercial extract.

*Grinding.*—To extract the tannin from any material it must first be reduced to a fine state of division, the degree of fineness depending upon the material, and may be either chips or powder, as found suitable. The actual method of grinding, as well as the machinery employed, will vary with the material and method of leaching chosen.

*Cone mill.*—The cone mill works on the same principle as

the ordinary coffee mill, and is used almost exclusively for grinding barks. This mill (figure 115) consists of a casing, on the lower part of which is a toothed cone, which rotates within the lower part of the casing. The action may be likened to the cutting effect of a pair of shears. The upper part of the casing opens up into a hopper which holds the

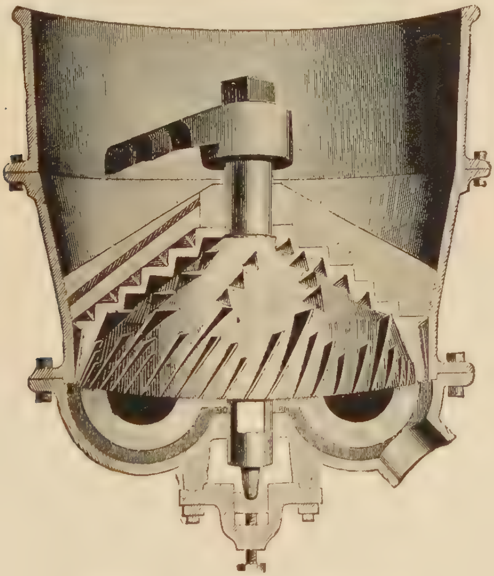

Figure 115.—Eureka bark mill.

bark. As the bark works down through the cone it becomes ground, the degree of fineness being regulated by adjustment of the cone. This machine is designed to work on dry material, but can be used for wet bark with no danger of clogging.

Another type of mill designed for the same purpose consists of a horizontal conical runner, set with breaker knives, which cuts the bark into small pieces, and drops it into the circular casing adjoining. This also is set with knife-blades across which the bark is forced by the rotation of heavy cast-iron arms and is shaved to any degree of fineness. The ground bark then passes out through the base to the conveyor.

For certain materials, such as myrabolans and the like, the bark mill cannot be used to the best advantage. It has been found that these materials can be best crushed by using a disintegrator or some form of roller mill. The disintegrator is a cage-like machine having heavy arms, which travel at high speed in a cylinder. This machine produces an excessive amount of dust and is rather a dangerous fire hazard. A better type of mill for this purpose consists of two corrugated rollers through which the material is passed. The distance between the rollers determines the fineness of the product.

The grinding of wood is usually accomplished in two stages, first by chipping the wood at an angle or directly across the end with machines of which two types are most commonly used. What is known as the "hog" is in general use in the United States.

The hog chipping machine consists of a cylinder cast with a deep V-shaped depression on each side of which the knives, twelve in number, are set, through slots placed alternately and equidistant. Fitting the V depression is a throat or shearing plate bolted to the foundation frame, relative to which the knives must be set so they will just clear to obtain a clean cut instead of a smashing or splintering action. The shearing plate being adjustable, any degree of knife-set may be obtained. Just what this set should be is a matter of individual judgment and requirement. The greater the set the greater the capacity of the machine and also the power required to drive it; the chip is, of course, larger and requires larger machines and more power to reduce it to a suitable size in the second stage. A fair knife-set gives not only a smaller chip, but one better shaped, as splintering is avoided.

The capacity for chipping cord wood varies from 2 to 5 cords per hour, and here we have an illustration of the importance of small things in manufacturing, for a variation of an eighth of an inch in the set of the knife will vary the cut of the machine almost the full extent of the capacities just mentioned, besides seriously interfering with the secondary

reducing machine and the ultimate yield of extract. The hog, for a capacity of about 4 cords per hour, or 160 cu. ft., requires about 200 h.p. to drive it.

*Disc chipper.*—The other type of chipping machine is known as the disc chipper, and consists essentially of a heavy cast-iron disc, about 6 feet in diameter, mounted on a shaft. The knives, usually six in number, are set in slots cut radially or tangentially through the disc, and work against a shear plate on the same principle as the knives of the hog. The wood, however, is fed to the machine at right angles to the direction of rotation, and at a point about mid-distance between the center and outside edge of the disc, whereas with the hog the wood is fed against the faces of the cylinder. The wood may be fed either at an angle inclining to the disc or horizontally, the method depending to some extent upon the final disposition of the spent chips. In any event the best results are obtained only with a forced feed, most suitably of the "shotgun" type, which is nothing more than an elongated engine cylinder with a ram on the end of the piston, and fitted with an automatically operated slide-valve to secure the quick return of the ram after the stick in process of being chipped has been cut up. The capacity of this machine is only about half that of the hog; but it requires much less power in proportion to the quantity of wood cut, and also gives a cleaner cut, with less dust, and consequently a chip which more readily yields its tannin. The importance of this will be seen later. It also reduces the work of the secondary machine to a minimum.

In both types of machine the quantity and quality of chips, to say nothing of economy of power, are not a little dependent upon keeping the knives and shear plates sharp, so the knives must be changed at least every 6 hours—and oftener if necessary—and the shear plate as frequently as the edge becomes rounded, which, considering that it is case-hardened, is astonishingly frequent.

*Secondary reduction.*—From the chipping machines the wood passes to the second stage of reduction which is neces-

sary not only to further comminute the chips, but also to render them of uniform size before extraction. The importance of this will be understood if we assume that the extractors have a capacity and efficiency based upon chips of a given size. If the size is too large or the chips are irregular the efficiency is no better than the effective extraction of the largest chips, and some chips are over-extracted, others scarcely wet through, resulting not only in loss of yield but also irregularity of product.

The machines used for secondary reduction are of the swinging hammer type. The operating part of the machine consists of a central shaft carrying a series of plates, to which the beaters or hammers are loosely suspended, so that they hang or cluster around the center when the machine is not running. Upon starting the machine, the centrifugal force causes the hammers to assume a radial position. Just clearing the ends of these hammers a bar grating is set, conforming to the circle described by the hammers when at full speed. The bars cross at right angles to the direction in which the hammers rotate. This bar grating performs the double function of acting as a series of shear plates and as a screen, which is designed to permit chips of the proper size only to pass to the conveyors which carry them to the extracting department, the size of chip being determined by the width of space between the bars.

The efficiency of these machines is largely governed by the condition in which they are maintained. Both hammers and rack bars must have the shearing edge kept in condition, which means a rather heavy repair account, as the edges in neither case last more than a few days; which is not surprising when we realize that during a day's run of 24 hours, the rack bars receive the impact of the wood between them and the hammers over three million times.

As good yields of extract, combined with economy, cannot be obtained unless the preparation of the wood is kept under constant control, to this end the chips should be tested at least three times during the 24 hours. A convenient method of

doing this is to screen two or three pounds of chips through a set of three screens superimposed in a tight box. The size of the openings is best at $\frac{3}{8}$ inch, $\frac{1}{4}$ inch, and 12 holes per lineal inch; and the frame 9 by 12 inches inside measurement. The weighed chips are placed on the top ($\frac{3}{8}$ in.) screen and shaken with a rotary motion until all that will pass through it. The screens are then taken out and the four divisions are weighed separately, and the percentage of each is calculated.

A good preparation should leave no chips in the $\frac{3}{8}$-in. screen, not over 20 per cent in the $\frac{1}{4}$ in., and 70 per cent on the 12-mesh; and there ought not to be over 10 per cent of dust in the bottom of the box. An excellent preparation should show no chips on the two upper screens, while the particles passing through the lower should not exceed 10 per cent at any time.

**Leaching.**—Having been reduced to the required degree of fineness the material is next treated with hot water to dissolve or extract the soluble portions.

The common method of extraction, and the one that is simplest in operation, is the press leach. This consists of a number of tanks arranged in what is known as a battery, usually six in number. The liquor from one tank is forced by gravity to flow into the next in order and so on through the series, the same idea being carried out as described under the press system in making sole leather. A better conception of the process of leaching may be secured by following the process through the different stages:

Assume that the leaches have been working for some time, and the strongest liquor has been run off to the cooler or to the evaporator: This leaves six tanks full of bark, of which five contain liquor. The tank from which the liquor has just been drawn holds the least-extracted chips. Calling this tank No. 6, the liquor in No. 1 pit is pumped to No. 2. This forces the liquor from No. 2 into No. 3 and so on until No. 6 is full. In tank No. 1 now remains the bark which has been extracted with six different liquors, and in so doing prac-

tically all of the tannin has been removed. The spent bark in No. 1 tank is now removed or "pitched" and the tank is filled with fresh bark. Fresh water or spent liquor is run into tank No. 2 which causes an overflow into tank No. 3 and so on through No. 6 into No. 1, which by means of proper connections now becomes No. 6. The liquor from what was at first No. 1 tank, but now is No. 6, is pumped to the cooler or evaporator and the liquor in what was No. 2 tank, but now is No. 1, is pumped to the next in series and the spent bark pitched.

The tank containing the strongest liquor is called the head leach, while that containing the weakest liquor is known as the tail leach.

The leach tanks are generally round, and are provided with a false bottom under which are steam pipes for the purpose of heating the liquor. In pressing the liquor from one leach to the next, the same precaution is taken as in a press-layer system; that is, the liquor must run downward through the leach in order that the incoming liquor may enter the bottom, thus forcing the outgoing liquor off the top. The transfer of the liquor is made either through wooden troughs or copper tubes by means of plugs or valves. The flow may be directed into any tank desired.

The cooler mentioned above is a large tank or number of small tanks where the liquor may be held until cool enough for use in the yard.

The heat during leaching should be moderate, as excessive heat tends to darken the liquor and produce a dark leather. For very light-colored stock, leaching is often carried out in the cold.

*Sprinkler leaches.*—Some tanners and extract manufacturers use a sprinkler leach. In this system the liquor is pumped from the bottom of the leach, and by means of a revolving sprinkler is allowed to spray onto the top of the bark in the next in series. Although the system no doubt produces a strong liquor, there is danger from oxidation and consequent loss of tanning material.

*Autoclave system.*—The systems mentioned above are all

conducted at ordinary atmospheric pressure. A pressure diffusion unit on the other hand consists of a series of from 6 to 8 cylindrical copper vessels or cells, usually of about 200 cubic feet capacity, capable of working under a pressure of 15 to 50 lb., which may be operated either on the decoction or the continuous diffusion basis, the final results in either case not differing much.

Each unit or battery is piped for steam, water, and air in a manner which permits of its being operated in the same way as open leaches, the difference being that, after filling with wood, the cover is bolted down and the leaching is performed under a pressure of 15 to 30 pounds.

The time of treatment in the autoclave varies with the kind of wood and the degree of fineness. The time, of course, is much shorter than in open leaching, being reduced to a minimum, from 36 to 48 hours being required to accomplish the complete extraction of the wood. Liquors made by the autoclave system contain much more sugar than those made in the open leach. Just what causes the increase in sugar is still somewhat of an open question. The liquors, as they come from the autoclave, go to the cooler, the clarification tanks, or the evaporators.

**Clarification.**—Following extraction, the next step is that of clarifying and de-colorizing the liquors. If a simple bark extract is desired it is only necessary to remove the dust and small particles of wood carried through the false bottoms or strainers of the extractors. This may be and is usually done by precipitation in large receiving tanks, although a more desirable method is to filter the liquor through a rough filter, after which it is ready for concentration.

One important point should not be overlooked, that is, the temperature of the liquor should be maintained as nearly as possible to that at which the liquor is run off. Cooling entails a waste of heat, and, unless pre-heating is practiced, the capacity of the evaporating apparatus is much reduced. The temperature can, of course, only be maintained by rapid handling and adequate insulation to prevent radiation.

In case of de-colorizing, and by that is meant the actual removal of the coloring substances by means of a coagulant, either chemical or organic, the process is somewhat more complex. Chemical reagents capable of precipitating coloring matter are comparatively numerous, but are not in general use in the United States. Most of them are defective on account of the residual acids or bases left in the extract, which render them injurious to the leather. The only advantages they possess are that it is unnecessary to cool the liquors to bring about the desired precipitation, also their cheapness

The best de-colorized extracts are unquestionably produced by the use of blood albumen, for which the dried packing-house blood of commerce is employed. The usual mode of procedure is to cool the liquor to about 90° F., and, while it is being agitated, add a strained solution of the blood in a series of fine sprays, the quantity depending upon the degree of de-colorizing desired. After the mixture is homogeneous, the temperature of the liquor is raised to 125° F. to ensure complete coagulation. It is then allowed to stand until clear, when it is drawn off for concentration. The precipitate is usually drawn from the bottom of the tank and passed through a filter-press to recover all the liquor possible. While by this means it is possible to produce an excellent product, possessing superior tanning qualities and suitable for tanning almost any kind of leather, it is somewhat expensive on account of the high cost of blood and the unavoidable loss of tannin.

In addition to blood albumen, several other substances such as lead acetate, aluminum sulphate, barium chloride, and casein have been employed, all of which, however, combine to some extent with and cause a loss of tannic acid.

An old method, but one which is time-consuming, consists in allowing the extract to stand undisturbed for several days. In this way the insolubles settle and the clear liquor may be drawn from the top.

A method frequently used to brighten extracts consists in treating them with sulphurous acid. To accomplish this, sulphur dioxide gas is allowed to bubble through the liquor.

Bleaching in this way does not actually destroy the color, but simply reduces it to a colorless compound which may re-appear when the leather made from it becomes dry.

Certain tanning materials, such as hemlock and quebracho, contain more or less insoluble tannin, which may be rendered soluble with alkalies or alkaline sulphites. Several brands of clarified extracts containing sodium bisulphite are therefore on the market.

These extracts, as a rule, are not effective, excepting when applied to heavy leather in the stronger liquors of the yard. Applied in the tannage of light leather they are more effective, and a proper bleaching agent, intelligently added to the extract, not only improves the color, but renders the tannage much more rapid and mellow, also giving greater tensile strength, pliability, and less danger from grain troubles.

Clarification and de-colorization being completed, the next step toward finishing the process of making extract is that of concentration to a heavy syrup or powder, in which form the product is delivered to the tanner.

**Concentration.**—From both an economic and quality standpoint, proper concentration is as important as any of the previous stages, and the same principles of rapidity and low temperature govern success or failure in producing a high-grade article.

Concentration of the extract involves the removal of the excess water from the light liquors, and, when it is considered that with the open system of extraction the quantity of water to be evaporated is about 17, to 1 of extract, and by the closed system say 10 to 1, the provision for doing so must be quite liberal. A plant producing 10,000 gallons of 25 per cent tannin extract per day has to evaporate from 100,000 to 170,000 gallons, or from 833,000 to 1,416,000 lb., of water daily. Should this have to be done under atmospheric pressure or open boiling it would require from 50 to 85 tons of coal, or its equivalent, daily. However, concentration in these days is accomplished altogether by boiling *in vacuo* or under

reduced atmospheric pressure, so that much less heat is necessary.

The apparatus employed is usually known as a multiple-effect evaporator, of which there are several types, the most used being known as the standard type, which consists of 3 or 4 copper vessels or pans, which, for the capacities previously mentioned, would be about 9 ft. in diameter and 12 to 14 ft. in height. These pans are arranged so that the vapor arising from the boiling in the first is carried to the second, and so on in order to the third or fourth, as the case may be. The lower section of each effect consists of a drum, fitted with two heads, which are tubed in a manner similar to a vertical steam boiler, but the tubes are much more numerous, a 9-ft. drum containing from 1000 to 1200 tubes, the number depending upon their diameter.

Steam is admitted through the shell of the drum, and the heat communicated to the liquor from the outside of the tubes. In the center of the drum is a large tube from 18 to 24 inches diameter known as the well or down-take. The purpose of this is to maintain a proper circulation of the liquors: any fluid will always move away from the hottest part or point of a heated surface, which, in this case, is the wall of the tubes. The result is that, when the liquor has become sufficiently heated to boil, it ascends the tube and is projected some distance above it. This gives the vapor generated in the tube an opportunity to escape, with the surface evaporation induced by the reduction of the atmospheric pressure. The liquor confined by the walls of the pan then falls through the down-take to the bottom to re-ascend the tube and continue the process, the liquor gradually increasing in density as it passes from one pan to the next.

The space above the drum, known as the vapor space, consists of two parts, namely, the belt and the breast or dome. This space is necessary for the liberation of the vapor without extrainment, which means the carrying over of any finely divided spray of liquor to the next drum or the condenser, where it would be lost with the water of condensation. Sur-

mounting the tubular neck of the breast is a separator, consisting of two concentric tubes with side openings diametrically opposite each other, the idea being to cause the stream of vapor to impinge upon the walls and thus cause a final separation of vapor and liquor.

The first effect is heated with live or exhaust steam, the condensation from which is usually returned to the boiler. The second, third, and fourth are heated with vapor from the preceding phase. The vapor from the last passes to the condenser, usually of the spray type, and escapes with the condensing water.

Vacuum in the first two or three effects is maintained by a vacuum-pump, which also removes the water of condensation. The last effect is connected by way of the condenser to an independent pump, which in all large apparatus operates on what is known as the dry system.

After concentration, it only remains to cool and give the extract time for a final settling, when it may be pumped into tank-cars or barrels for shipment.

In recent years some demand has sprung up for powdered extract, and, should this be desired, the liquid extract is dried by means of a film dyer, which consists of an internally steam-heated drum enclosed in an air-tight casing. While the drum revolves, it comes in contact with a trough of extract, and, picking up a film, carries it along the greater part of the revolution (during which time it is thoroughly dried) until it comes in contact with a scraper set against the drum, which removes and drops it into a suitable receiver. During the process the vapor is removed by a vacuum-pump.

A recent innovation in producing solid extracts consists of spray drying. In this process the material to be evaporated is forced hot through a small opening into a high-vacuum chamber. The fine spray readily gives up the moisture content, the solid material falling to the bottom of the drum.

Powdered extract has no advantage over the liquid, except in saving freight charges. In fact, rather the reverse is true,

as every exposure to heat has a deleterious effect on the product, both as to color and decomposition of the tannin.

Having described the general methods employed in leaching or extracting vegetable tanning materials let us consider some of their most important sources.

**Chestnut wood.**—Botanically known as the *castanea vesca,*

Figure 116.—Chestnut trees; giants of the forest.

it belongs to the oak family (figure 116), and is easily distinguishable by its narrow, pointed, serrated leaves, its fragrant flower which grows in slender axillary catkins, and its fruit, the latter two of which are unlike those of any other tree. It may also be readily recognized when out of leaf by its bark, which, when young, is gray and smooth, but is heavily ridged in the mature tree. It is found from Maine to Alabama and Georgia, and west as far as Kentucky and Michigan. It does not, however, grow in great abundance over the entire territory mentioned, and, considered from

a tanning-material standpoint, it is nearer correct to describe its bounds as within the environs of the Appalachian Mountains. It is one of the most beautiful of American trees, growing in great profusion and to considerable dimensions. Where it stands close, the tendency is toward height rather than girth and spread, and trees 80 to 100 feet in height are

**Figure 117.—A flume on the chestnut wood operations.**

not unusual. As to girth, it varies greatly, this being a matter of age, but, as it grows rapidly, it often attains great size.

Referring to the quick growth of the chestnut tree, it is so rapid that it has been termed the weed of the forest. Numerous cuttings in various localities show that it will grow as much as 6 to 8 inches diameter in 10 years, and from 15 to 20 inches in 25 years. Besides this feature, it is reproduced with great facility, a characteristic unfortunately not possessed by any other tannin-bearing wood of importance. After cutting the virgin forest it will spring up again in great

abundance, not only as saplings but as offshoots from the decaying stump left after felling the virgin tree (like the redwood of California); and not infrequently the stems on one stump will aggregate more wood than the virginal trunk, so in 20 to 25 years a second cutting may be made. With proper care such a system could be continued indefinitely,

Figure 118.—Flume terminus for chestnut wood.

and comparatively small areas be made to yield a large supply of tannin for generations.

In Virgina, West Virginia, Tennessee, and North Carolina, chestnut timber grows in great abundance, and large tracts of well-timbered land exist upon which 75 per cent or more of all the timber standing is chestnut. It is in these States that the production of chestnut tannin is mostly conducted.

The air-dried wood, the operations of handling being shown in figures 117 and 118, contains an average of about 8 per cent of tannin, but it varies a great deal and may run as high as 14 per cent. The age of the tree, exposure, and climatic

conditions all have their effect upon not only the tannin but the other extractive constituents of the wood.

Besides tannin, it contains considerable quantities of gallic acid, the pre-existence of which is doubtful, as it may result from the decomposition of the tannin.

The extractive matter obtained in the manufacture of chestnut tannin extract usually contains about 60 to 65 per cent tannin and 35 per cent to 40 per cent non-tannin substance. The tannin is distinctly of the pyrogallol group, yielding pyrogallol when heated, and remaining soluble when tested with bromine water and hydrochloric acid-formalin solution. When pure, it also gives the blue-black color said to be characteristic.

The non-tannin substances consist chiefly of sugars, which reduce Fehling's solution, gallic acid, pectose compounds, resin and ash, but they are no better understood than the tannins. Their quantity and composition in the tanning extract are largely a question of manufacture, and much remains to be done before we can say much about them. The sugars of chestnut wood, in common with those of barks, are valuable in the tannery on account of the acid they produce; thus their presence adds to the value of chestnut tannins.

As a tanning material, chestnut tannin has been chiefly confined to the production of sole, belting, and other heavy leathers; but there is no reason why it cannot be employed for many other classes of leather when properly made and used. On account of its abundance, cheapness, and excellent qualities, chestnut tannin bids fair eventually to become the staple basis for the tannage of all heavy vegetable-tanned leather.

A few years ago the chestnut blight struck the trees along the North Atlantic coast, and before steps could be taken to retard its ravages, thousands of trees were destroyed. It is felt, however, that proper treatment has been discovered and that the danger is now past.

**Oak wood.**—The wood of all the oaks yields considerable though varying quantities of tannin, the American oaks ranging from 3 to 5 per cent in the air-dried woods. In Europe, tanning extracts are made from a number of the oak woods,

the product being held in much favor, if one may judge from its value, which is from 20 to 25 per cent higher than the chestnut extracts.

Among the oaks employed for this purpose are the *Q. robur*, *Q. cerris*, *Q. pubescens* and their varieties. These grow chiefly in southeastern Europe, Austria, Hungary, and Jugo-Slavia being the chief sources of supply. In America, no oak-wood extract is produced. Attempts were made years ago to utilize the wood of the chestnut oak or rock oak, *Q. prinus*, the wood and bark being all ground up together. The composition of the extract, however, did not, apparently, meet the ideas of the American tanner at that time, so the attempt failed, and no further investigation has been made up to this time.

In Europe, only the waste material from the sawmills is utilized for extract, the body of the tree being more valuable as lumber; and, in order to produce a merchantable article, the bark, which contains red coloring matter, is carefully discarded. The tannin of the oak woods is similar in most respects to that of chestnut. It belongs to the pyrogallol group and gives the same reactions.

Extract made from oak wood appears to differ little in composition and color from American chestnut, but it usually contains more soluble non-tannin than the average European chestnut. A recent analysis of a sample of southeastern Europe oak-wood extract gave approximately 38.6 per cent total solids, 25.0 per cent tannin, and 13.2 per cent soluble non-tannin. The purity was 65 per cent, or almost identical with American chestnut.

**Barks.**—Tanning in all countries, until recent times, was conducted with native materials derived from the most convenient sources of supply, and as in Europe and North America, the immense forest areas, now sadly depleted, furnished what was at one time considered an inexhaustible supply of oak and hemlock bark, it naturally followed that the tannins derived from these barks formed the basis of all tannages on both continents for a very extended period.

In Europe and Great Britain the oak barks predominated, while in North America hemlock bark has been more extensively used, although oak bark has been, and is used where plentiful, especially in the Southern States.

Speaking of the oak barks, it seems that the source of supply of tannin is not confined to any one species, and almost any oak bark that would tan has been employed. There are altogether over 30 species and varieties of oak trees.

Abroad, the *Q. robur*, or English oak, has been most extensively used. This tree bears a greater resemblance to the American white oak than any other, though it is interesting to note that the bark of the latter is scarcely recognized here as a tanning material. This tree, which is more valuable now for its timber than for its bark, grows throughout Great Britain and Europe and still furnishes, through reforestation, a considerable quantity of tan bark. In Europe, the custom is to peel the bark from the tree while it is still young enough to be smooth, the age of the tree being from 12 to 20 years. The bark, it is claimed, then has a greater tanning efficiency and yields a better color than that from mature timber.

Many plantations have been started during the past 50 or 60 years, which are said to have yielded profitably. In handling these plantations, the system is to divide them into as many sections as it takes years to produce bark suitable for peeling. When the bark has grown sufficiently, the first section is peeled, the timber removed, and the land re-planted or allowed to sprout from the stump of the first growth. The next year the second section is harvested, and so on in rotation, so that a continuous supply is secured. Europe is much in advance of the United States in the line of conservation, the necessity for such expensive development not yet having arisen on the American continent. In fact, it is doubtful if such a system could be successfully applied here, as it is obvious that the labor and attention must be costly, and, as long as tanning material is as cheap as it is now, it is not likely to appeal to the investor.

The American varieties of oak are more numerous than

those of Europe, there being about twenty-eight, but the chestnut oak or rock oak, (*Q. prinus*) is the only one which furnishes tanning material in great quantity. The range of this tree may be said to be confined, like the chestnut, to the Appalachians, where it grows in great abundance; although the supply is diminishing rapidly, and will soon be exhausted, as it does not reproduce as rapidly as chestnut. In appearance it is very similar to some of the other oaks, but, while in foliage, may be readily distinguished by its leaf, which is unlike any of the others. In appearance it is something between the chestnut and the English oak. In Winter, the expert may distinguish it by its bark, which is smooth and of a silvery gray color in the young tree, and rough and much ridged in the mature tree. The bark becomes rough after the tree has attained a diameter of 8 inches or so.

In the United States, bark is peeled from trees at all ages, and consequently the quality and tannin content vary a great deal.

In past years the tree was felled for its bark alone, the timber being considered of little value Now, however, little is cut that is not manufactured into lumber, a change which has made for conservation, the peel being governed to a considerable extent by the market for the timber.

Prime chestnut-oak bark contains an average of about 10 per cent of tannin, and yields 18 to 20 per cent of soluble extractive matter, which is rich in acid-forming sugars. It is on this account considered one of the most valuable of all tanning materials. It has now become too scarce and costly to use alone, but when it was available it was unsurpassed for the manufacture of sole and belting leathers. In combination with other materials, it yields a high class of carriage, harness, and other leathers requiring a full, mellow, and firm tannage.

The tannin of the chestnut oak responds to the catechol reactions, and is unlike some of the other oaks in this respect, as several seem to contain tannins of both groups in large proportions.

On the Pacific Coast there is another variety of oak tree which is deserving of more study than has been given to it, and which bears the same relation to the tanning industry of that region that the chestnut oak does to the East: It is the *Q. densiflors* or California oak. It is still abundant in California and Oregon, growing chiefly on the lateral spurs of the Pacific coast ranges, which makes it somewhat inaccessible. The bark from this tree is the richest of all the known oaks in tannin, frequently containing from 17 to 20 per cent, with as much as 30 per cent of soluble extractive matter. It yields a rich red liquor, more like that of hemlock in appearance than of chestnut oak. The sole and harness leather tanned with it is of a distinctive character and of excellent quality, being much more mellow and with less tendency to break than ordinary oak-tanned stock.

It seems to differ from most other tannin in that it is difficult to blend with other materials on account of an apparent selective action. In other words, when blended with chestnut liquors, the hide seems to take up the chestnut first, with 'the result that, not only is the characteristic color lost, but the texture of the leather is materially affected.

*Chestnut bark.*—In the manufacture of chestnut-wood extract, no attempt is made as a rule to separate the bark from the wood proper, both being extracted at the same time. There is, however, a certain demand for chestnut-oak bark extract and when this is required it is extracted separately.

*Oak bark.*—Nearly all species of oak contain more or less tannic acid in the bark and wood. Catechol tannins predominate in the bark, although this also contains a certain amount of pyrogallol tannins, ellagitannic, and quercetannic acids.

If cut while the sap is rising, the bark separates readily, while timber cut at other times offers some resistance in stripping. The peeled bark is laid in piles several feet high and is so arranged that the water is shed somewhat as from shingles on a house. This is absolutely necessary to prevent damage to the bark. When oak bark is used it is generally leached at the tannery. No true oak-bark extract is on the market, al-

though a so-called extract is sometimes offered for sale. Such extract is usually found to be modified chestnut-oak bark. In some of the Southern tanneries and extract works a certain amount of oak-wood extract is prepared; but the quantity is comparatively small.

*Hemlock bark.*—After the oak tanning woods and barks, the bark of the hemlock tree, *tsuga canadensis*, ranks next in importance and, in North America, it probably still occupies the premier position.

The hemlock is a cone bearer of the spruce family, and is one of the most beautiful evergreens of the forest. Conical in shape, with plume-like horizontal branches, it gives an impression of great dignity, and, in the forest, of much solemn beauty. The bark is of a red color, and its leaves are short and linear, growing on little petioles, which distinguish it from any other conifer. In Spring the foliage is tipped with new growth of a light green, while in Winter it is dark and lustrous.

It is widely scattered in one or more of its varieties all round the world. The species are five or six in number, and grow principally in northern latitudes. In eastern North America it ranges from Hudson Bay to northern Georgia, and from the East to the Mississippi. The great hemlock forest, however, does not extend south of Pennsylvania and West Virginia, the timber south of those States being only found in restricted areas, mostly following in narrow belts the small water-courses of the mountains.

In western North America another variety of this tree, the *tsugas mertensiana*, which is richer in tannin than the eastern, flourishes along the Cascade Range and north from there along the mountain ranges of British Columbia and Alaska, where it is still very abundant on account of the remoteness of its position, half a continent separating it from the great centers of the leather industry.

In the Eastern States the supply is fast approaching the vanishing point and of the thousands of square miles once covered with practically unbroken hemlock forest, compara-

tively little remains, and it would doubtless have entirely disappeared but for the introduction of other tanning materials and the increased value of the timber.

In Canada there are still considerable areas, which, however, are so rapidly disappearing that it is only a matter of a short time until the hemlock forest disappears from the eastern section of the continent.

In northern Europe two species of this tree are found in quantity, and also in Asia, while other varieties grow in India, China, and Japan. From descriptions given by various authorities it would appear that the Oriental hemlock is very similar to the American.

The bark of the hemlock contains varying quantities of tannin, this being governed by climate and exposure. As a rule it will yield about 10 per cent of the weight of the air-dried bark, with about 16 to 18 per cent of soluble extractives. The tannins are of the catechol group, and the soluble non-tannins are rich in sugar. The liquors are of a brilliant red color and are soluble with difficulty, and like most of the catechol tannin bearers, are not readily filtered clear.

As far as North America is concerned, it has been the tanning material par excellence, and probably the only one with which it is possible to produce excellent leather of all kinds. It seems as well adapted for the lightest colored fancy or upper leather as for the heaviest sole, and, previous to its scarcity, it was used almost universally in the whole range of leathers made on this side of the Atlantic.

**Quebracho.**—From the standpoint of production and consumption, quebracho wood tannin is as important as chestnut wood.

The quebracho tree is generally given in botanical books as *aspidospermia,* but this name covers several varieties, which, with one or two exceptions, are of little or no use to the tanner. The variety with which he is chiefly concerned is that growing in Argentina and Paraguay, and known as the *quebracho colorado* or, as distinguished by botanists, the *loxopterygium lorentzii.* The common trade name quebracho

is said to be derived from the Spanish word *quebra*—to break, and *hacho*—axe, or break-axe, this nomenclature doubtless being due to the great hardness of the wood.

The quebracho is an evergreen tree, which, in common with all others, is of all heights and sizes. It is said, however, occasionally to attain a height of 100 feet. In the forest its distinguishing features are its usually erect stem and its wide-

**Figure 119.—Carting quebracho logs to port of shipment; trees in the background.**

spreading crown. The branches at the top grow almost vertical, but, as they descend, become gradually more horizontal until they droop, forming a somewhat umbrella-like top.

The leaves are rigid and lanceolate or spearhead-like in shape, and the flowers occur in terminal panicles.

The bark is thick, and remarkable for the thickness of the internal or corky layer, which often constitutes one-half of the entire thickness.

The wood is very heavy, too heavy to float, and of a reddish-brown color, which takes a fine polish.

This tree (figure 119) is of extremely slow growth, taking

from 400 to 600 years to attain a girth of 6 to 8 feet, a characteristic which makes its disappearance only a matter of time, for it certainly is being cut much faster than it grows.

The supply, as far as at present ascertained, is confined to Argentina and Paraguay, the Chilean supply, it is said, having already been exhausted. There are, however, large quantities still standing on the grand chaco or forest section of the two countries first named.

Unlike the hemlock, oak or chestnut forests of America, where immense bodies of these timbers grow almost to the exclusion of any other, the quebracho grows scattered throughout and mingled with the other growths, nor is the forest like that of our mountainous country. The land on which it grows is for the most part flat or rolling, and the forest is divided into belts, a belt of timber alternating with a cleared space of pampa or prairie.

It was estimated some years ago that there were 175 million tons of timber standing, but, as this estimate was apparently based on the chaco being an unbroken forest, its accuracy is open to question.

The manufacture of quebracho tannin is conducted for the most part in Argentina, a number of factories operating on the Parana river and its tributaries, to which the logs are conveyed, in some instances, hundreds of miles, by rail and boat. These logs are also transported to Germany and the United States where the tannin extract is produced in large quantities.

Quebracho has been used for tanning in Chile and Argentina for a long time, but it is only within the last 20 years that Europe and the United States have utilized it to any great extent. In the latter country its use grew tremendously for some years, more being consumed here than in all of Europe. At present the annual consumption of the States is about 90 million pounds of solid extract per annum, representing about 56 million pounds of tannin, or the product from 156,000 tons of wood. The quantity used in Europe is probably not quite so great. Germany is the largest consumer on

the Continent, and, although some is used in France and Great Britain, it is not looked upon as favorably as in America.

The wood contains about 18 per cent of tannin and yields 22 to 25 per cent of extractive matter, of which 80 per cent is estimated as tannin and 20 per cent non-tannin. The tannin belongs to the catechol group, giving a green color with ferric alum, and precipitates with bromine water and hydrochloric acid-formaldehyde solution. This, however, only applies to crude and some clarified extracts. It has been found that some of the so-called clarified do not yield precipitates with either of the above reagents, which is due to the presence of the chemicals used for rendering the extract soluble, or clarifying it, as it is usually termed.

The non-tannins differ materially in their structure and proportions from those of oak and hemlock barks and chestnut wood. Some tests show that an extract containing 10 per cent non-tannin contains about 2 per cent gallic acid and 1.25 per cent sugars: the remaining 6.75 per cent is probably gum and pectose matter, although that still remains undetermined.

The extracts, which are of a strong red-brown color, are soluble with great difficulty in water, and, in order to obtain anything like economical or satisfactory results, it is necessary to resort to some one of the several methods of clarifying them either by sedimentation or chemically rendering them soluble, the most common method being to treat the extract with sodium bisulphite.

As a tanning agent, quebracho is employed for all classes of leather, being especially adapted when clarified for the tannage of light leathers where weight and plumpness are not a consideration. In conjunction with hemlock and oak bark or their extracts, it is extensively used in the production of bag, case, patent, and automobile leathers; and many satisfactory tannages are produced in the above lines where it forms almost the entire tannage. For heavy leathers, such as sole, belting, and harness, it is invariably used in conjunction with other materials, as it does not contain the necessary sugars for acid-forming, which in these tannages is indispensa-

ble; nor does it make solid leather of good weight when used alone. When clarified, however, it penetrates rapidly, and on account of its high purity, is useful in strengthening up a yard which has become saturated with inert non-tannins.

**Valonia.**—This tanning material is obtained from the acorn cup of the Turkish oak (*quercus ægilops*), which grows in Asia Minor, and, being shipped from Smyrna, is termed "Smyrna valonia." The amount of tannin in this grade of valonia is about 40 per cent. A lower grade of valonia grows on the islands of the Grecian Archipelago and is known as "Greek valonia." The tannin content of Greek valonia ranges from 20 to 30 per cent. In both varieties the tannin is mostly of pyrogallol derivation.

Valonia is of value to the tanner for its weight-giving qualities. It also deposits considerable bloom, not only in the leather, but on the surface. In most tanneries valonia is used as a dusting material in the layers. The tannic acid from valonia is found both in the cup and in the beard hair. As a rule, however, no attempt is made to separate the two materials. In a few places where they are separated the ground cup is used for dusting and the beard hairs are extracted. The extract from the beard hairs produces a certain quantity of acid in the yard, while the cup gives practically no free acid.

In the use of valonia it has been shown conclusively that Smyrna valonia gives about 25 per cent more weight than Greek valonia, hence the former is much more prized by tanners.

In Asia Minor the fruit ripens during July and August, and the acorns, which are shaken from the trees, are allowed to dry on the ground. They are then gathered and transported by camel and rail to Smyrna, where they are placed in storage and allowed to ferment, during which time the acorn contracts and falls from the cup. The cups are handpicked, the largest and finest, known as *prima*, going to Trieste, the second selection (*Inglese*) is shipped mostly to England, while the remainder, known as *natural*, is sent to other countries.

In Greece, the best fruit is gathered in April, while still green, and is known as *chamada*. The second quality is beaten from the trees in September and is known as *rhabdisto*, while a third grade is collected after the fall rains, and being dark in color, is termed *charcola*.

**Mangrove bark.**—This tanning material is derived from the bark of the mangrove tree, which occurs widely distributed in practically all tropical island districts. There are over 20 different species of mangrove, all of which contain more or less tannic acid ranging from 8 to 30 per cent. The most largely used species of mangrove is that known as *rhizophora mucronata*, although *bruguiera gymnorrihiza* and *ceriops condolleana* are somewhat employed. The mangrove tree requires considerable moisture and is therefore found in swampy or marshy land, also along muddy sea-coasts. The trunk is irregular and spready, making gathering difficult. The bark is stripped and sold as such to the tanner, or is extracted and sold as mangrove or cutch extract. Mangrove is used by many tanners of sole leather, mixed with other barks and extracts. In some South American countries the entire tannage consists of this material. No doubt the difficulty of securing the bark has been the cause for its retarded utilization. There are thousands of acres, however, of this valuable tanning material available, and there is no question but that eventually it will become an important raw material in the manufacture of leather.

**Gall nuts.**—*Quercus infectoria* is the source of Turkish galls. The galls are caused by insects which lay their eggs on the leaf or bud and so produce an abnormal growth. The best gall is obtained before the insect escapes, and contains from 50 to 60 per cent of tannin as gallotannic acid. This material is the principal source of pure tannic acid. The *quercus infectoria* sometimes bear large galls known as "Apples of Sodom" or "rove." These are caused by a different insect. Chinese and Japanese galls are produced by the action of an aphis on a kind of sumac.

**Sumac** (*rhus coriaria*).—Sicilian sumac is obtained from

a bush of which the leaves and twigs are used. The bushes begin to bear in the second year, but the best material is obtained from the mature bush. Cropping is done by pruning off the shoots or picking the leaves by hand. The leaves are then dried either in the field or on rocks, and are afterwards separated from the stems by heating. The leaves are then ground to a powder under edge-rollers and shipped in bags.

*Mascolino.*—This is the best grade of sumac, coming from Palermo, while *feminella* is a weaker grade from other parts of Sicily.

After the sumac has been submitted to the first grinding, it is passed through screens and the coarser particles are re-ground.

Good sumac contains from 25 to 27 per cent of tannin, while some samples may run much higher. The tannin is mostly gallotannic acid, with some ellagitannic acid and a coloring matter.

Sumac is the best tanning material known for light colors and soft leathers, and is therefore largely used in making Moroccos, sheepskins, and skivers. It is also largely employed to improve the color in darker tannages.

*Rhus glabra.*—This is a sumac found in the Southern American States, and is largely used in place of Sicilian sumac. It contains about 25 per cent of tannin, but produces a much darker leather than that made with Sicilian sumac.

*Rhus typhina.*—Known as "stag-horn," is a variety of sumac found in Virginia and contains from 10 to 18 per cent of tannin. The color produced with this sumac is nearly equal to that obtained with Sicilian sumac.

In Virginia the leaves are collected and dried, but no attempt is made at selection. The leaves are usually taken when full of sap, sometimes being simply stripped from the twigs; and sometimes the whole stock is cut and the leaves are allowed to wither in the sun. In such cases the leaves, when partly dry, are transferred to sheds and spread out in a thin layer on a rack. The time required for drying varies with the weather conditions and may even take a month for a per-

fect cure. When in proper condition they should be dry and brittle. Although Virginian sumac is fairly high in tannic acid it does not produce as light a color as is obtained with Sicilian sumac.

The grinding of sumac is usually done in the edge-runner and the resulting powder sifted to remove twigs and stems. French sumac is obtained from a poisonous shrub found growing in the south of France called *stinco*. It is low in tannic acid, and although it has no tannin value, it is used mostly as an adulterant of true sumac.

**Gambier.**—This material is derived in most part from a climbing shrub, *uncaria gambier*, found in the Dutch East Indies; or from *terra japonica*, also known as *catechu*. It is also cultivated by the Chinese in a very crude manner. The first crop is taken about three years after planting and the leaves are taken two to four times annually, the life of the shrub being about 15 years. After cropping, the leaves are thoroughly chopped and placed in kettles with boiling water. Concentration, with constant stirring of the liquor, is carried out until a syrup is obtained. The leaves and twigs are then removed with a fork and the excess liquor is allowed to drain back into the kettle. The heavy extract is then placed in tubs to cool, and when in a pasty condition it is again placed on a flat surface and cut into cubes. These cubes, which are about an inch long, are placed in a shed on bamboo trays and dried out with wood fires. Cube gambier is dark brown on the surface, but pale on the inside. Its tannin is a catechol-phloroglucol derivative. It produces a soft tannage, and is much employed in the production of glove leather. The tannin content of good cube gambier is from 50 to 65 per cent.

A more common and cheaper form of gambier is that known as "block gambier," which in place of being cut into cubes is run into large oblong blocks weighing about 250 lb. each. These blocks, which are of a pasty consistence, are wrapped in matting and shipped. Block gambier contains from 35 to 40 per cent of tannin.

Modern factories have been established in Sumatra and other

places, which are equipped with the latest approved apparatus for extraction and concentration. A greatly improved product is therefore available and is known as Indragiri gambier.

**Myrabolans.**—This tanning material is obtained from the unripe fruit of the *terminalia chebula,* a tree growing to a height of from 40 to 50 feet. The content of tannin, which runs from 30 to 40 per cent, varies with the maturity of the fruit. Of the various kinds, the "Bombays" are the least unripe, while the "lean greens" are the most unripe. The more unripe the fruit the higher the tannin content. Bombays are light in color and have a smooth surface skin, with coarse wrinkles. J's (Jubbalpores) and U's (Urigorlas) are harder than the Bombays and have finer wrinkles. Lean greens are the most unripe fruit and produce a color very closely resembling sumac. The tannin present is of the gallotannic and ellagitannic acid derivation. The nuts should be hard in character and not of a waxy or soft appearance, otherwise difficulty is encountered in grinding. This softening is likely to happen, however, if the nuts are stored in a damp place.

Not only does the fruit from this tree contain tannin, but the bark is also high in tannic acid. Extracts from the bark show high percentages, but they have not been introduced to the trade to any extent.

**Divi-divi.**—This tanning material is obtained from the dried pods of the *cæsalpinia coriaria,* a native tree of Central America growing to a height of about 30 feet. The pods contain from 40 to 45 per cent of tannin of the pyrogallic and ellagitannic variety. When used in a concentrated liquor it produces a heavy and firm product very desirable in the manufacture of sole leather. In dilute liquors, and when used in the drum or paddle, it produces a very fair color on light leather.

**Algarrobilla.**—This tanning material is found in Central America and is derived from *prosopis pallida.* It appears on the market as long pods with a fairly high tannin content. Some of this material has been sent to the United States as a mixed tanning material, but its use has not become general.

**Mimosa bark.**—This bark from the *acacia arabica* is used

largely in India for tanning kips. It contains from 12 to 20 per cent of catechol tannin.

**Wattle bark.**—The bark is from various species of Australian *acacia,* and on account of the high tannin content, running in some cases as high as 50 per cent, it bids fair to become a very important factor in the production of leather. A great deal of work has been carried out with this material during the past few years, and the results obtained look very promising.

**Palmetto.**—The saw palmetto of Florida, *sobal serrulata,* contains considerable tannin in the roots, and from it an extract may be made which produces a light-colored leather. As the supply of palmetto is very large, it offers a raw material for extract manufacturers which should compete closely with some of the other common extracts. In about 1904 an attempt was made to introduce this tanning material, but for some reason it did not meet with an enthusiastic reception. Recent attempts, however, have been somewhat more encouraging, and it is now being used successfully in tannage where a soft and mellow leather is required.

**Sulphite cellulose extract.**—In the manufacture of wood pulp by the sulphite process, the ligneous matter is dissolved, leaving the cellulose in a fibrous condition. The liquor thus formed is purified by removing the objectionable constituents, and the resulting product is concentrated by evaporation until a liquor of the consistence of an ordinary tanning extract is obtained.

This extract, when tested by the hide-powder method, shows about 25 per cent of a substance absorbed by the hide powder. It is not claimed by the manufacturers that this substance is tannic acid, but it is claimed that this absorbable material will produce or help to produce leather. On account of its low cost and certain other valuable properties sulphite cellulose extract is used in large quantities with entire satisfaction. It may be used alone, but better leather is produced by mixing it with other tanning extracts. It finds its largest application as a filler in extract tannage of sole leather where it seems to

give weight and aids in producing a light-colored product. A series of tests carried out by the author indicates that sulphite cellulose extract may be used to advantage as a bottom in the manufacture of heavy leather. By so doing, the stock is given a light colored bottom which remains even after the treatment with other tanning materials.

## CHAPTER XVIII

### SYNTHETIC TANNING MATERIALS

During the past fifty years, chemists have been endeavoring to produce tannic acid synthetically, but up to the present time their efforts have been without success. There are, however, a number of products on the market which are spoken of as synthetic tanning materials, but this term is incorrect and misleading, as none of them bears the faintest relation to true tannic acid. Practically all of these compounds are derived from coal tar, and are either condensation products or derivatives of aromatic compounds.

The first really important work along these lines was when Stiasny succeeded in changing the well-known condensation products of phenol and formaldehyde into a water-soluble compound, and showed that the product possessed tanning properties. This reaction is accomplished by acting upon two molecules of phenol-sulphonic acid with one molecule of formaldehyde, and then neutralizing the resulting product with sodium carbonate. The product at first prepared by Stiasny was originally called "syntan" but on account of objection was later called "neradol."

For the production of what is now sold as neradol D a mixture of ortho, meta, and para cresol is employed. This compound met with fairly general application before the World War, and when the German patents were taken over by the Chemical Foundation, it was one of those included in the list. Several firms in the United States are now making a similar product. Its chief use is as a pre-tan in the production of heavy leather. The hides are usually run in a solution of this material for about 24 hours at a density of 60° bk., when they are transferred to strong tan liquors. Nera-

dol and its substitutes may also, it is claimed, be used in conjunction with other tanning materials.

Not only has it been shown that phenol and cresol are capable of producing compounds possessing tanning properties, but many other products have been tested with varying degrees of success. Among these compounds might be mentioned *p*-amidophenol, chlorophenol, trinitrophenol, pyrocatechine, resorcine, hydroquinone, benzoquinone, mono-chlorohydroquinone, orcine, pyrogallol, gallotannic acid, naphthols, naphthol derivatives, anthracene, anthracene derivatives, anthraquinone, and anthraquinone substitution products.

Some of the above chemicals produce condensation products having tanning properties, while others give sulphonation products with marked tanning efficiency.

From the first announcement of Stiasny's success in producing a substance which would transform hide substance into leather, chemists as well as manufacturers became interested in further extending our knowledge of these materials. Tanners are in a credulous state of mind, and are willing to give these new substances every advantage of experimentation. This is no doubt due to the fact that everyone realizes that our supply of natural tanning materials is shrinking, and we all appreciate the wonderful results that followed the synthesis of alizarine with the consequent building up of a synthetic dyestuff industry.

During the World War, the Germans were forced to develop every source of domestic tanning material, and as a result they resorted to the following materials: Spruce bark, chestnut wood, sumac, willow bark, birch bark, hops, pine bark, chestnut hulls, lentiscus, walnut bark, elder bark, and sulphite cellulose. They also resorted to the synthetic materials which were sold under the names of triumphite, neradol D, neradol N, neradol ND, and ordoval, all of which are condensation products of formaldehyde with phenol, cresol, and naphthaline derivatives. These synthetic materials as well as others were used alone or in combination with the inferior vegetable tannins mentioned.

American chemists are producing many of these synthetic materials, and are continually endeavoring to bring them to a higher degree of perfection.

An article of exceptional merit, which is recommended to the reader, is that by George Grasser in the January, 1921, *Journal* of the American Leather Chemists' Association. Some of the most striking features, however, are quoted below:

Dihydroxybenzene (pyrocatechol) yields with sulphuric acid a sulphonic acid, soluble in water, which assumes a deep blue color upon the cautious addition of formaldehyde. This liquid stands heating to 100° C. without precipitating insolubles. However, if some formaldehyde is again added there follows immediately a brownish-black color with the precipitation of considerable quantities of insoluble condensation products. On the other hand, if the sulphonic acid is diluted a third with water, formaldehyde then added, and heated on the water-bath, a brown color results with complete union of the formaldehyde to the water-soluble condensation product.

The tanning test with this condensation product, which was partly neutralized as in the above test, yielded after a 24-hour period an intense dark coloring of the grain, while the inner part of the pelt was white but completely pickled. After 48 hours more, this dark color, however, penetrated the whole thickness of the pelt and tanning was completed. The washed and oiled leather was soft, full, tough, and possessed an even gray color.

Meta-dihydroxybenzene (resorcin) can also be easily converted by concentrated sulphuric acid into water-soluble sulphonic acids of brown color. If this sulphonation product is then diluted one-fourth with water, cooled down completely, treated with a few drops of formaldehyde and heated on the water-bath for combination of the formaldehyde, cooled down again, treated with a very little formaldehyde, and then heated gradually on the water-bath while stirring, a condensation product is obtained as a mass soluble in water to a brown color.

The usual tanning test proceeded extremely rapidly; and the pelt was completely tanned through in 24 hours with a light brown color. The lightly oiled and dried leather showed a greenish yellow color, was plump, tough, and soft.

Para-dihydroxybenzene (hydroquinone) was converted into the water-soluble sulphonic acid with concentrated sulphuric acid at 100° C.; this, treated with a little formaldehyde at ordinary temperature, solidified immediately to a white, solid mass, which was soluble in water, and which had completely fixed the formaldehyde. If this mass, however, was heated for a longer time at 100° C., a light brown color appeared and the condensation product was less soluble in water. A small excess of formaldehyde and moderate warming leads to dark, violet-colored, insoluble condensation products.

Tanning, carried out in the usual way, proceeded somewhat more slowly and after a 7-day period yielded a brown-colored, tough, and soft but rather thin leather.

Of the trihydroxybenzenes, only pyrogallol and phloroglucine were used in this investigation. Pyrogallol, upon sulphonation with concentrated sulphuric acid, yielded a violet-colored, water-soluble sulphonic acid, which, when treated with formaldehyde, at first while

cooling and finally while warming, solidified and yielded a deep red-brown, water-soluble mass.

Tanning carried out in the usual manner, yielded after 24 hours a dark-colored grain and white, pickled interior. The dark-colored part, however, penetrated the whole pelt quickly and was complete in 7 days. The resulting leather possessed throughout a dark color, was plump, soft, and tough.

In connection with the phenols, quinone may be briefly discussed, its use as a practical tanning material being first described in German patent 206,957 of April 30, 1907. According to this process, only 400 grams of quinone are used to 100 kilograms (kg.) of pelt, and the pelt is tanned with it in 5 hours in a drum. Leather produced in this manner, in the course of tanning assumes first a red, then a violet, and finally a brown color, and its resistance to water, acids, and alkalies will be much greater than with all other known tannages. The chemical properties of this tannage have also given a motive to theoretical consideration and according to Thuau (*Coll.*, 1909, 363, 211) in tanning with quinone-like bodies, leather is formed by the quinone entering into reaction with the amido group of the protein molecule according to the equation:

$$\underset{\text{(hide)}}{2R.NH_2}+2C_6H_4{<}^{O}_{O}=C_6H_4{<}^{OH}_{OH}+\underset{\text{(leather)}}{C_6H_4(O.NH.R)_2}$$

Fahrion demonstrated that during quinone tannage the content of active oxygen in the quinone becomes smaller, and only the amido group of the hide protein can effect this. Dianilin-quinone might be named as a known analogy.

Distinct quantities of hydroquinone can be actually detected in a used solution of quinone. Hide can also be tanned by saturating with hydroquinone and oxidizing with air. When such hide is taken from the hydroquinone bath and brought into the air, in the presence of alkali, it is colored, first red, then violet, blue, and finally brown, and is converted into a quinone-tanned leather. There is still to be mentioned that quinone is also able to effect a pseudo-tannage. If quinone is left standing for a while in water, a nearly black, amorphous body is formed which is almost insoluble in water, but which is abundantly absorbed by hide powder. However, it is not changed into such an insoluble form as is the case with other tanning materials.

From the series of nitro compounds, trinitrophenol (picric acid) $C_6H_2(NO_2)_3OH$ was investigated. If picric acid in concentrated solution is used for a tanning experiment, the pelt is entirely penetrated by it in a few days. However, oiling hide tanned in such a manner is difficult, since the fat is poorly absorbed. After drying, a fairly soft, but thin leather is obtained which easily loses color and tastes intensely bitter. These disadvantages prevent the general utilization of picric acid as a tanning material.

If picric acid is sulphonated with concentrated sulphuric acid and formaldehyde gradually added, condensation takes place to a water-soluble product which precipitates gelatine. By the introduction of bromine, however, a water-insoluble product is formed.

Of the aromatic alcohols, the di-alcohols show a characteristic behavior because they condense with sulphonic acids with the elimination of water, without the assistance of aldehydes. Besides, mono-, disulphonic acids and the higher sulphonated products of phenols, the homologous cresols, xylenes, and naphthenes (German patent 300,567) also enter into the reaction. The condensation between the components takes place extraordinarily easily, with liberation of so much

heat that the process proceeds quantitatively. On the other hand, dilute solutions must be heated to 100° C. when the process is completed in a few minutes. The products obtained are exceptionally pure, crystalline, and with their power of precipitating gelatine show a powerful capability to tan hide. The reaction is as follows:

$$2\,{}^{OH}_{HSO_3}\!>C_6H_3CH_3 + HO.\,C_6H_3<^{CH_2OH}_{CH_2OH} =$$

$$2H_2O\ HO.\,C_6H_3<\begin{matrix} CH_2C_6H_2CH_3<^{OH}_{SO_3H} \\ CH_2C_6H_2CH_3<^{OH}_{SO_3H} \end{matrix}$$

Of the aromatic acids, the behavior of salicylic acid ($C_6H_4OH.COOH$), is especially to be emphasized. This can be sulphonated very easily at a high temperature by concentrated sulphuric acid and the sulphonated product, which forms a white solid mass, is soluble in water to a completely clear solution. This mass mixed with about one-third of its weight of water and treated at 120° C. with formaldehyde, changes rather rapidly into the condensation product. A reddish-brown liquid results, which is miscible with water to a clear brown solution.

A piece of pelt placed in a 3° Bé. solution of this condensation product was converted within three days into white, plump, and tough leather. Obtaining synthetic tannins from nuclear homologues of salicylic acid is the subject of a patent declaration (German patent A. 28,901). Cresotic acid (hydroxytoluic acid, $OH.C_6H_3CH_3COOH$), also gives similar results.

*Condensation of naphthalene derivitives.*—As the phenol-sulphonic acids can undergo condensation, so also is it possible to condense naphthalene and naptholsulphonic acids, with elimination of water, to tanning substances. If naphthalene is heated with sulphuric acid, there is formed, at a lower temperature (about 80° C.) *a*-naphthalene-sulphonic, at a higher temperature (160° C.) and with excess of sulphuric acid, *b*-naphthalenesulphonic acid which is also formed by heating the *a*-acid with sulphuric acid. Both of these acids are deliquescent, crystalline substances. On longer heating of concentrated sulphuric acid with naphthalene the 2.6 and 2.7 naphthalene-disulphonic acids are formed, while a series of isomeric naphthalene-trisulphonic acids are obtained by indirect means. From *b*-naphthalene sulphonic acid, *b*-napthol can be produced; *a*- and *b*-naphthols in turn are able to form a large number of *a*- and *b*-napthol sulphonic acids, and mono-, di-, and trisulphonic acids. Almost all of these acids represent important raw material for the production of dye-stuffs.

The simplest condensation of *b*-naphthalene sulphonic acid is attained after several hours' heating at 135° C. and 20 mm. pressure (Austrian patent 61,061). The product thus obtained is a cheesy mass which reacts very strongly acid. By neutralization of this acid to a lower acidity, a gray-colored cheesy mass is produced which is easily soluble in water to a light grayish-brown liquid. This product shows a good tanning action on hide.

The condensation of *b*-naphthalene sulphonic acid proceeds much more energetically with the use of formaldehyde. For practical production, the naphthalene sulphonate is condensed with formaldehyde at 85° C., and this condensation product forms the neradol N of the trade; greater dilution and neutralization brings it to the same tannin content (33 per cent) as neradol D, and this product

appears in trade under the name of neradol ND (German patent 290,965). Both products are capable of changing hide in a very short time into a normal leather of white color.

Besides formaldehyde other substances are able to effect a condensation of naphthalene sulphonic acids. If, for example, sulphur chloride is allowed to act on *b*-naphthalene sulphonic acid, a light brown, solid mass of strongly acid character is obtained. This, neutralized as usual, produces a grayish-brown solid mass, which is very easily soluble in water to a light-brown liquid. A tanning experiment made with this solution yielded a light-brown and fairly soft leather.

*A*-naphthol dissolved in hot concentrated sulphuric acid and heated for some time on the water-bath forms *a*-naphthol sulphonic acid. This, moderately diluted with water and mixed cold with formaldehyde, shows no change. On warming the mixture on the water-bath a brown precipitation occurs. This turbid liquid treated with gelatine produces a heavy flocculent precipitate. If the turbid solution which has been heated on the water-bath is treated with caustic soda, then solution is effected with the formation of a light yellow liquid, which also remains clear after the addition of an excess of acetic acid and gives a heavy precipitate with gelatine. The hot concentrated *a*-naphthol sulphonic acid treated with sufficient formaldehyde, effervesces violently and yields a dark brown insoluble condensation product which is soluble in caustic soda. This alkaline solution treated with an excess of acetic acid, also precipitates gelatine copiously.

If *b*-naphthol is dissolved in hot concentrated sulphuric acid and heated for some time on the water-bath, a brown, viscous solution of *b*-naphthol sulphonic acid is formed. This, moderately diluted and mixed with formaldehyde, remains clear, but is colored to a dark reddish yellow by heating on the water-bath; however, it remains soluble in water and is abundantly precipitated by gelatine. This condensation product, super-saturated with caustic soda, yields a deep blue solution, which does not precipitate gelatine; on the addition of acetic acid it is colored brown and remains clear and will then precipitate gelatine copiously. If concentrated *b*-naphthol sulphonic acid is heated on the water-bath with formaldehyde, a condensation to a dark reddish-yellow, water-soluble mass occurs which will give a copious precipitate with gelatine.

The action of these condensation products in moderately concentrated solution yielded in a few days a light-brown leather which is very similar in its properties to vegetable-tanned stock.

The practical utilization of the production of synthetic tannins from naphthols and aminonaphthalene sulphonic acids is protected in German patents 293,042, 293,640, 293,693, and 303,640.

In a recent article which appeared in *Chimie et Industrie,* vol. 11, page 1024, and translated in the *Journal* of the American Leather Chemists' Association for February, 1920, Professor E. Nihoul gives a full description of synthetic tanning materials and among others mentions the use of quinone as a tanning agent as follows:

*Quinone: its action on gelatine and hide.*—In 1908, Meunier and Seyewetz published results of their researches upon the rendering insoluble of gelatine by the action of the following organic com-

pounds: Phenol, resorcinol, orcinol, hydroquinone, pyrocatechin, gallotannic acid, pyrogallol, *p*-aminophenol, chlorophenol, picric acid, monochlorhydroquinone and the mono- and disulphonic acids of beta-naphthol.

The phenols only slightly soluble in water, such as alpha- and beta-naphthols, as well as the simple and substituted amines and aminophenols, either when existing in salts or as free bases, do not give precipitates with gelatine solutions. But if conditions are provided favorable to oxidation, both phenols and aminophenols give precipitates which are insoluble in boiling water. This fact led the investigators to experiment with oxidation products of the phenols, especially ordinary quinone. They discovered that the gelatine quinone precipitate is the most stable form of insoluble gelatine at present known, for it resists not only the action of boiling water, but even of dilute acids and alkalies. The time required to render gelatine insoluble by means of quinone is less than two hours at 15° C. The quinhydrones react similarly, only more slowly. On the other hand, experiments with formaldehyde gave a product which dissolved completely under repeated treatment with hot water and which slowly lost formaldehyde when subjected to dry heat. Furthermore it is dissolved in the cold by hydrochloric acid and dilute alkalies.

The same results were obtained with hide as with gelatine, either with phenols and aminophenols in the presence of oxidizing agents, or with quinones without oxidation.

Comparative experiments with other substances capable of reacting with hide substance show that a liquor containing only 1 part of quinone per 100 parts by weight of raw pelt renders the latter insoluble, transforming it into a leather whose resistance to the action of water, acids, and alkalies is superior to that of any other leather known—chrome leather included—and whose resistance to wear is at least equal to that of the best leather tanned with oak bark.

The analysis of used quinone liquors reveals the presence of hydroquinone, which proves that a part of the quinone was used to oxidize the hide substance, while the remainder entered into a stable combination with the oxidized hide. Since hydroquinone is readily oxidizable, the yield will be greater if means are provided to re-oxidize it. The provision of conditions favorable to oxidation favors this tannage, and the use of catalyzers, such as the laccases, artificial peroxidases, and acetates of Mn, Ce and La, consequently produces a better and more rapid tannage. Meunier has pointed out that oxidases are to be found among the soluble matters given up by the hide during tanning.

*Methods of preparation and properties of quinone.*—In general, quinones can be obtained by oxidation of the corresponding paradiphenol compounds and can also be produced when more than two hydroxy groups are present, provided two of these groups are in the para position. They are formed likewise by oxidation of numerous compounds derived from the phenols such as *p*-phenol sulphonic acid and *p*-aminophenol, but the method often employed in laboratories is to oxidize, by means of chromic acid, certain mono-substituted derivatives of benzene, such as aniline.

Among the chief properties of quinone of interest to the tanner are the following: It is soluble in cold water to the extent of only about 0.5 per cent., but dissolves to a considerably greater extent in warm or acidified solution. In practice, it is dissolved in slightly acidified boiling water, but this should be done in a closed tank, as the product is volatile and easily carried away in the vapor. Acid solutions are stable for a much longer period than neutral or alkaline solutions, and light is harmful in causing oxidation, Quinone

solutions should not be brought into contact with metals nor put into wooden vats which have been used previously for vegetable tannins, as they will darken in color and lose their property of giving a clear tannage. Quinone is readily kept in the crystalline state either in wooden or tinned containers. It is dissolved only as needed and not more than will dissolve.

*Application in the tannery.*—Quinone alone, employed to the extent of 1½ parts to 100 of pelt, is capable of completely tanning the stock in a few days. It would therefore seem at first sight that quinone tannage constitutes an ideal process both from the standpoint of speed and of cost. In reality this is not the case, and the reason lies in the fact that the leather is sold by weight, a procedure which was established in times past, when hides sold at a price reasonably higher than that of tannin, in order to induce the manufacturer to get enough tannin into his leather to ensure complete tannage. Since then the situation has changed, and hides have increased in price out of all proportion to that of tannin. The result of this has been, especially in the case of rapid tannages, an increase in proportion of tannin, combined or not, in the leather, until now some of the better grades often contain not more than 30 to 35 per cent of hide substance.

It is quite evident that under these conditions tanning with quinone alone cannot compete with tanning with vegetable extracts, excepting for light leathers sold by the square foot. Nevertheless, on account of its great value as a preliminary tanning agent, it has become an article of considerable importance. Before the appearance of quinone, formaldehyde was employed preliminary to vegetable tanning, with the object of isolating and strengthening the hide fibers so as to enable the hide to be put into concentrated liquors without harm. But the formaldehyde does not remain fixed, and experience has shown that after storing for some months these leathers undergo change, becoming hard. No such difficulty is found with the use of quinone, and hides first treated with quinone fix vegetable tannins with remarkable speed, without any disadvantage either to the leather or to the modern methods of rapid tannage. Furthermore, its use has increased rapidly in the manufacture of all kinds of leather, particularly sole leather.

The *Leather World* of March 10, 1916, devoted considerable space to the use of quinone as a preliminary tanning agent. It has been used for sole and strap leathers, where it has been demonstrated that such leathers possess greater resistance to wear than others not so treated. It has also been used for upper leather and has even been employed with chrome leather.

For box calf it is best not to shave the skins too deeply after the beam-house work, the quinone giving them sufficient suppleness. The operation consists in adding to a soak of 100 kilos of skin 600 grams of quinone and 300 grams of 80 per cent lactic acid. If the stock has been bated, the acid is unnecessary. For ordinary leathers, acetic acid is preferable. The tannage is then carried out with a one-bath chrome liquor, using only 60 per cent of the usual amount of chrome and neutralizing agent. Box calf made in this way is better than the ordinary in that it is more permeable to air and gives a shoe which is more hygienic and cooler in Summer; it is more supple and has a finer grain; and in dyeing, the black is distributed more uniformly, not only over each skin, but over all skins in the same lot, thus increasing the number of first-grade skins. When used for colored calf, the proportion of sumac and gambier can be greatly reduced and the grain is never hard or brittle. The same holds true for smooth calf, whether black or colored.

Preliminary quinone treatment of kidskins intended for shoes makes possible the use of one-bath liquors and makes the sorting for colors unnecessary.

During the past two years attention has been called to the use of several other organic compounds which possess tanning properties and which promise to open up a new field for the preparation of synthetic bodies for leather manufacturers. Most of the compounds are sulphonated products of the higher hydrocarbon compounds.

## CHAPTER XIX

### UNUSUAL TANNING PROCESSES

**Electric tanning.**—The first attempt to utilize electricity as an aid to tanning was by Crosse in 1850. Later, Ward continued the researches of Crosse, but without any marked success. From time to time since that date investigations have brought out new suggestions, but they all depend upon electrolysis of the tanning solution.

The first process which was at all successful was introduced by Meritens in 1874. In this process the usual tanning solutions were employed. On the bottom of the pit was placed a plate of graphite connected to the positive pole, the hides were entered, and a zinc plate was placed in the top of the solution. The zinc plate was connected to the negative pole and the current allowed to pass through the liquor, a regular 110-volt current being used. Tanning by this treatment was said to be complete in 35 days. The cost of the current in this process is an item which must be considered, and unless it can be obtained cheaply it is prohibitive.

Although other attempts were made, the next large-scale experiments were undertaken in Sweden, when an alternating current was employed and copper electrolysis used. The time required was 45 days. In this process the hides were suspended parallel to the electrode. The current was thus caused to pass through the hides.

A process devised by Worms and Balle consists in the use of ordinary drums. On the inside of the drum, on opposite sides, were placed copper disks connected by rods to the source of current. From 1000 to 1200 lb. of hides were placed in the drum and about 75 gallons of chestnut liquor added, and the drum set in motion. Through the trunnion $1\frac{1}{2}$ gallons of oil of turpentine was introduced, and the current turned on.

The intensity of the current was 10 amperes with a tension of 70 volts. The tanning bath was strengthened from time to time. When well struck through, the current was turned off and the drum run for another interval.

It was claimed that bull hides could be tanned in 5 or 6 days by this process, while lighter hides required a shorter period.

A process devised by Place consisted in placing the hides in closed vats provided with agitators, and along the bottom, a series of comb-like conductors. The hides were placed in the vats containing a liquor standing at about 5° Bé. The first treatment extended over a period of 8 hours with an intensity of current of 20 amperes. The hides were then thrown into another vat with 5° Bé. liquor, but no current was passed through the liquor. Agitation, however, was employed, and the process for the heaviest hide was complete in about 100 hours.

Although other processes have been and still are constantly being suggested, no process has as yet been sufficiently successful to warrant serious consideration.

**Vacuum tanning.**—Many attempts have been undertaken to make this commercially feasible, but up to the present time none of the vacuum processes have met with success.

**Seymour-Jones method.**—By this method the de-haired and washed hides are placed in a 0.5 per cent solution of formaldehyde, where they are allowed to remain 4 days. The grain is then fixed by placing on frames in liquor of mixed tanning material standing at 45° bk., a rocker system being employed. The hides remain in this liquor for 48 hours. They are then transferred to a drum and enough liquor at 75° bk. to cover the stock is introduced. A small quantity of turpentine is added to prevent frothing. After the hides have been entered the drum is set in motion and run for 2 hours. The door is opened and the drum allowed to remain at rest for 4 hours. It is then run again for 3 hours and allowed to rest over night. The next day the drum is run in the same manner as on the first day, when by night the stock should be

tanned through. The hides are dried in a fairly warm room, sammied, scoured, oiled off, and dried in the cold. They are then re-tanned with strong extract in a mill, running for 15 minutes. The hides are next oiled off with a sulphonated oil on the grain and again set-out. Another coat of oil is applied and the stock dried in a cool loft. When dry, they are waxed, rolled, and finished.

This method is especially successful on heavy calf and is claimed to be applicable to heavy hides as well.

**Organ leather.**—The principal uses of leather in the manufacture of organs have been thoroughly investigated by the United States Bureau of Standards, and are as follows:

1. Bellows
   (a) Gussets
   (b) Hinges
   (c) Valves
2. Pneumatic pouches or diaphragms
3. Pneumatic valves

Alum-tanned sheepskin appears to be used by most manufacturers for bellows, gussets, and hinges. Leather for the hinges of the folds of the bellows is required to be firm and well stretched. A soft, pliable, unstretched leather is required for the gussets or corners where it is necessary that the leather fold in or out as the bellows move up or down. It is necessary that the leather be free from any groan or squeak while in motion.

A small, rectangular piece of leather is used for bellows valves. This leather is held over the valve-opening in the side of the bellows by tacks or a strap. The leather should be firm and well stretched so that it will lie flat and not curl up on the edges. Bark-tanned sheepskins, chrome-tanned cowhide, and chrome-tanned calf are used for this purpose.

For box or pouch pneumatics, sheep or lambskin skivers are generally used. A skiver is defined as the grain split of a sheep or lambskin. The split is taken off when the skins

are in the rawhide state. These are mostly vegetable-tanned, but occasionally some alum-tanned skivers are used.

A variety of leathers are used for pneumatic valves. The most common are alum-tanned and chrome-tanned calf or cowhide leather. Some sheep and goat leathers are also used.

For miscellaneous joint packings, bark-tanned or chrome-tanned sheep fleshers are generally used, while in some cases seal fleshers are employed.

**Leather for player-pianos.**—The uses for leather in player-pianos follow the same general classifications as described for organs, the chief difference being the leathers used on the pneumatic valves. While a variety of goat, sheep, cowhide, and calf leathers are used, the most common is chrome calf re-tanned in a vegetable-tanning material. Leather used for this purpose should be firm, similar to calf for shoe uppers. The flesh side generally rests on the valve-seat, which is metal, and forms an air-tight joint. The grain side is glued to a wooden disk on the valve-stem and is preferably napped to facilitate the gluing. This leather should be free from acid, as, if this is present, corrosion of the valve-seat may occur, causing sticking. It should also be dry to prevent sticking to the valve-seat, which thus prevents the quick and positive action necessary for successful operation.

Any kind of leather that will not harden in hot climates, will not stick to the valve-seat, does not contain acids which cause corrosion of the valve-seat, and is firm, can be used satisfactorily on valves. No definite standard has been adopted, and the same manufacturer often uses different kinds of leather, according to what may be obtained to the best advantage.

*Pneumatic pouches.*—Manufacturers have experienced their greatest difficulty in securing leather of the desired qualities for use on pneumatic pouches. Sheep or lambskin skivers are almost universally used for this purpose.

Briefly, the operation of the action of a player-piano may be described as follows: Air is pumped in from the room through the openings in the tracker-bar and is exhausted into

the room through the bellows valve. When one of the perforations on the music-roll passes over its corresponding opening on the tracker-bar, air is pumped through a tube or duct to a chamber directly beneath the pneumatic pouch or diaphragm. This causes the pouch to be raised. A small cardboard disc mounted on the center of the pouch engages with the valve-stem, raising it, together with the leather disc, which has been seated on the valve. This action allows the air to be exhausted from the small wing-bellows by suction, which causes the bellows to collapse. The collapsing of the bellows in turn allows, through suitable mechanical devices, the particular note to be sounded. When the opening on the music-roll has passed over its opening on the tracker-bar the suction is relieved, the pouch falls, the valve is closed and the wing-bellows fills again with air.

It will be seen that this leather diaphragm is a most important part of the action. If it is too tight, stiff, heavy, or leaky, the valve movement will lag and difficulty will be experienced.

A skiver for this purpose must be soft, pliable, light in weight, uniform in thickness, and as free as possible from "pin-holes" or larger openings. It is not required to be air-tight, and leather of this type is naturally porous on account of the holes left when the wool is pulled. These holes are partly filled in the process of manufacture, but there are often many holes remaining through which light is plainly visible, and which would allow a sufficient volume of air to pass so as to affect seriously the positiveness of the action. On this account the skivers are carefully examined in the factory and those portions unsuitable eliminated.

It is difficult to secure skivers tight enough and of the thickness desired. On some small pneumatics skivers not more than 5/1000 or 6/1000 of an inch thick are required, while on larger pneumatics the thickness may reach 10/1000 or 12/1000 of an inch.

The leather must also be soft and stretchy, as it is formed into a pouch by a mold of spherical shape. The pouch is then

placed over the chamber in the player-board and the edges are glued to the board.

The quality of a skiver is entirely dependent upon the type of sheep from which it is taken. The nearer the animal is to a hair type the better the skiver will be, in that it will be finer grained and will have smaller pores or hair-holes, which, of course, will make it tighter.

The majority of the sheep are of the fine, heavy-wooled merino type, or closely approaching it. In order to allow sufficient space for the wool to grow on fine-haired sheep, nature provides ridges on the pelt so that it resembles a corrugated surface. These ridges are so high that they affect the quality of the leather produced and make it impossible to secure a skiver from these pelts suitable for piano manufacturers. Thus, the original source of skins for suitable skivers is from animals of the hair type, which, as a rule, are obtained from foreign countries.

Skins imported for this purpose are preserved by pickling, and are split after having the pickle withdrawn, but still contain some sulphuric acid which cannot be eliminated from the fiber. This necessitates the use of tanning liquors of such nature as to make the resulting leather feel relatively harsh. Foreign manufacturers can split the fresh skins directly in the limes and then drench or "puer," as the case may be, and send the splits directly to the tanyard. So-called "sweet liquors" can be used, thereby producing a soft and pliable leather.

It is believed that there is no factor in the working of the pickled pelts in the United States which would produce pinholes in the leather. The question of obtaining comparatively tight skins is chiefly a matter of selection. England splits more lambskins than are split in the United States, and thus has a larger volume of skins from which to make a selection. Also, there are tanners in England who make a specialty of preparing leather for the organ and piano trades, while in America no tanner does this on any large scale. In order to emphasize the importance attached to the selection, one manufacturer states that out of an annual production of

75,000 to 100,000 dozen skivers, he would not feel safe in offering over 1000 dozen suitable for use in piano actions.

The volume of business represented by the use of skivers in this industry has been considered relatively small. It is probable that the largest manufacturer would use about 2000 dozen per year, while the smaller manufacturer would use only 100 dozen per year, or even less. If the total were known it would probably represent a sizable volume of business. The American tanner generally, therefore, has not thought it worth while to solicit this business on account of its relatively small volume. Considerable work would be required in making the necessary selection, which would add to the cost. On this account it has been thought that the American tanners cannot compete with foreign tanners on the same price basis for the same quality.

*Substitutes.*—Rubberized fabric has replaced leather for covering bellows and pneumatic wing-bellows. This material possesses the advantages of being uniform and air-tight when first placed in use. It is necessary, however, to replace these fabrics, which fail in from 3 to 10 years' time, according to the operating and atmospheric conditions. This failure is due to the deterioration of the rubber which cracks and thus allows air to leak through.

A very thin, rubberized silk has been tried for pneumatic pouches in place of skivers, but its use was not successful. Its life is short, and in time the rubber coating hardens, thereby causing a loss in pliability. Leather is ideal for this purpose, and if the quality is right, it will last a lifetime.

The use of tanned cattle guts has been proposed, and some alum-tanned colons have been used. One manufacturer states that the alum-tanned guts are so affected by moisture that they dry out as tight as drumheads. One supply dealer has produced a vegetable-tanned colon which, it is claimed, will retain its pliable condition. This material is produced only in small pieces about 8 by 16 inches. It possesses the distinct advantage, however, of being practically air-tight under the pressures used in the instruments. Some difficulty has been

experienced in making and gluing pouches from this material, but it is believed a little study and care in handling will obviate this objection. The possibility of the use of whale and porpoise intestines is now being investigated.

The author has developed a process for making leather from the so-called bung gut, which answers all requirements for piano leather and is being favorably regarded by the trade.

**Shark-skin leather.**—For several years the author has been interested in the utilization of shark and porpoise skins for

Figure 120.—Hauling in netted sharks.

leather manufacture, and has investigated the methods of handling this class of raw material. Through this work he became acquainted with Alfred Ehrenreich, president of the Ocean Leather Co., who has also spent many years in the study of this subject, and through whose efforts the establishment of an entirely new industry has been made possible.

During several recent visits to the Everglades of Florida

and to Morehead City, North Carolina, the shark and porpoise have been studied in their native haunts, and the fact demonstrated beyond a doubt that it is possible to handle these fish in a commercial manner. As a result, the Ocean Leather Co. has now in operation at Morehead City a modern plant where the hides are removed and salted. In addition, the livers are rendered for their oil and the flesh is

**Figure 121.—Roping a shark.**

**Figure 122.—Landing a shark. Note skins on pier.**

converted into a high-grade fertilizer stock. Another station at Sanabal Island, Florida, is also operated by the same company.

*Catching and handling.*—The sharks are caught in nets of 8-inch mesh, 360 yards long and about 12 feet deep. As the boat picks up the buoy, one man standing in the stern pulls in the cork line, (figure 120), while another hauls up the lead. When the shark is brought up, a rope is placed over the tail (figure 121), or, in some cases, a hook is placed in the mouth.

If the fish is alive, it is killed by a sharp blow with an axe, and then lifted on board by means of a block-and-fall. In an average haul from 10 to 20 sharks are taken from each net.

On arriving at the dock, the fish are unloaded (figure 122), and the work of dressing is started at once. The first operation is to remove the fins and tail. The former are tacked on a rack and allowed to dry in the sun; they are used by the Chinese for making soup. The fish is then cut down the back, and a circular cut made over the neck and around the gills. The skin is finally removed in such a manner that only the holes of the pectoral fins and rectal opening remain in the pelt. The flayed skins are placed in salt for 24 hours, fleshed on the beam or machine, and placed in bundles for shipment to the tannery.

The livers are thrown into barrels, where they are allowed to remain for several days to disintegrate, and are then placed in steam-jacketed kettles and heated to boiling for about an hour. From the kettles the oil is run into washing and settling tanks, where the gurry is separated from the oil. The oil is then drawn into a second tank, again washed, and finally run to a third tank, where it is stored until ready for shipment. Exposure to the sun and rain effects more or less bleaching.

The carcass at present is used in the manufacture of fish scrap for fertilizer stock. Briefly, it is thrown into the hopper of a specially designed mill, where the flesh and bones are ground to a fine pulp, which is dried in a rotary dryer. This grade of fish scrap contains on an average 15 to 17 per cent of nitrogen expressed as ammonia.

*Treatment of skins.*—The shark skins as they arrive at the tannery, are soaked in water to remove the salt and are again fleshed. Skins for bag leather are limed and bated in the usual manner and tanned in bark. The tanned skins are then treated to remove the shagreen, and after washing and coloring are ready for the finishing process.

The skins to be used for shoe leather are not limed or bated, but are at once treated for the removal of the sha-

green. This so-called shagreen is a hard layer which covers the whole fish; it has the appearance of coarse sand paper, and is almost impossible to remove by mechanical means. The elimination of shagreen from the raw skins is a problem which has remained unsolved until recently. A process developed by the author consists in soaking the skins in an acid solution which accomplishes the removal of the shagreen in about two hours. By leaving skins in this solution for a week no damage is done. The skins are neutralized in a salt solution, to which soda ash is added from time to time. When free from acid the stock can be tanned by any of the methods now in vogue.

**Porpoise leather.**—Although porpoises are not as plentiful as sharks they deserve brief mention. Porpoises travel almost exclusively in schools, and are, therefore, usually caught in the purse seine (net). The method consists in surrounding the fish and then landing them on the beach. These fish vary in size from 3 to 30 ft. Their skin carries a heavy layer of blubber, which is split off and rendered to obtain lubricating oil. On the face of the porpoise is an extra heavy blubber known as junk, which, when rendered separately, yields a more valuable oil than ordinary blubber oil. In the jaw cavity is about 1 oz. of oil, known as jaw oil. This oil is carefully rendered and brings from $30 to $80 per gallon.

The top layer of hide from which the blubber has been split is limed to remove the rubbery surface and open up the fiber bundles. It is then tanned by either the oil or the vegetable process as applied for other kinds of leather.

# CHAPTER XX

## ARTIFICIAL LEATHER, DOPE SPLITS, AND PYROXYLIN FINISHES

**Pyroxylin.**—The application of pyroxylin finishes to cloth and leather has become a very important industry. This subject was well set forth in a lecture by Gillett Wyncoop, of the Anderson Chemical Co., before the tanning and leather chemistry students of Pratt Institute, Brooklyn, N. Y.

The uses of pyroxylin for coating fabrics, leather, and paper materials is an industry which has grown largely within the last 20 years. A chemist in England discovered that by mixing pyroxylin with castor oil or various other oils, and putting certain colors, either dyes or pigments, in the solution, coating this on a fabric, and then running it through a roller with a certain pattern engraved on it, gave a fabric which looked much like leather. It was pliable and did not crack easily, was waterproof, and would stand a great deal of wear and exposure to the atmosphere. About the same time certain industries in Newark, N. J., discovered these same properties, and in this manner began the manufacture of artificial leather and finished splits.

In the manufacture of artificial leather, pyroxylin, as a rule, is dissolved in a mixture of alcohol and amyl-acetate in about the proportion of 1 to 1½ lb. of pyroxylin, according to the grade of artificial leather desired, to a gallon of solvent.

*Solvents.*—One reason why the use of pyroxylin did not receive recognition earlier was on account of the solvents used in its manufacture. There were a great many solvents for pyroxylin, but few that would make a good film. Nearly all of the ethers, alcohols, aldehydes, and some of the hydrocarbon oils are solvents for pyroxylin, but only a few give proper results. Among the best solvents should be mentioned amyl-acetate, acetone, acetone oil, butyl-alcohol, ethyl-alcohol,

and methyl-alcohol. As a rule, however, a mixture of two or more of the above solvents is used rather than a single compound, a favorite mixture being amyl-acetate, acetone, and wood alcohol.

To dissolve cotton in wood alcohol it is necessary to have a grade of alcohol that is at least 94 per cent.

There are a number of substitutes for amyl-acetate, however, which can be used to advantage. One of the most extensively used today is ethyl-acetate. It has a boiling point near grain alcohol, around 79 or 80°, and if a solution is applied to leather or imitation leather, and the film is warmed by placing over hot pipes, the ethyl-acetate will attract very little moisture and thus will work satisfactorily. But unless it is 100 per cent pure it has little use as a substitute for amyl-acetate in dope finish. It is employed, however, fairly extensively in the artificial leather industry where goods, after spreading, are run over steam pipes or run through a chamber in which a blast of hot air is driven.

Ketones are very active solvents for the cotton, and will dissolve the cotton quicker than any other substance. Acetone is the most rapid solvent, but in practical use it is unsatisfactory, on account of its low boiling-point, about 56°, and quick evaporation. It will evaporate before the goods can be spread.

All of these solvents may be cheapened somewhat by dilution with naphtha or benzene. Pure amyl-acetate will stand nearly 50 per cent dilution with naphtha or benzene and still be a solvent.

*Procedure.*—After the pyroxylin is dissolved in the amyl-acetate and wood alcohol, a certain amount of castor oil or other oils is added (in artificial leather about 1½ to 2 lb. of castor oil to 1 lb. of pyroxylin is added to the solution). They are either dissolved separately and mixed or all are dissolved together. After the oil is added the color is introduced. In artificial leather the color should be a dry insoluble pigment. There is nothing especially objectionable about the dyes except that they are likely to "crock," that is, when rubbed with a wet cloth the color will rub off.

In the United States there are 8 or 10 large manufacturers of artificial leather. The pyroxylin solution is spread on all grades of material, some not much heavier than cheesecloth, up to heavy cloth weighing 2 lb. to the yard. At the present time some of these higher grades of cloth with a heavy coating are being used for even such high-grade leather substitutes as automobile cushions, but the chief use of artificial leather is for upholstering for indoor work. It can, however, be substituted for nearly every use to which leather is put, but, of course, is used as a cheaper product. It will wear as a rule as long or perhaps better than some of the cheaper grades of leather.

*Acid formula.*—Pyroxylin is a low-nitrated guncotton. In its manufacture not quite as strong an acid mixture is used as for the guncotton employed for explosives. The acid formula employed in making pyroxylin, that is, the grade which is used for artificial leather, is about 60 per cent sulphuric acid, 21 per cent nitric acid, and 19 per cent water.

This may be varied in a number of ways to suit the conditions and qualities of the pyroxylin required, for nearly every industry requires a slightly different grade of pyroxylin as to solvents and what is termed "viscosity." The higher the temperature at which it is nitrated the higher the viscosity.

Anything much under the percentage given will not dissolve cotton. Methyl-alcohol, or wood alcohol, has little effect on soluble cotton when it is absolutely pure. In technical work we usually specify to the manufacturer of the wood alcohol that it shall contain 10 to 15 per cent of acetone, this, as already stated, being one of the best solvents.

The general division of soluble cottons is as follows: A cotton that is insoluble in ether and alcohol or a mixture of the two (the latter is the old solvent that has been used for 50 years or more in making what is known as collodion solution), is classed as guncotton. In other words, guncotton is insoluble in ether and alcohol solution. This mixture can vary from 1 to 3 parts, respectively, or up to 3 parts to 1, respectively. The nitrated cotton is roughly divided into gun-

cotton and soluble cotton. A cotton with a high percentage of non-soluble is classed as insoluble cotton. Cotton of less nitration, soluble in ether, is called collodion cotton or pyroxylin. The dividing line is not distinct. Certain cottons, when highly nitrated, are soluble in this solution, whereas perhaps nitrated in another way with slightly less nitrogen in the cotton would not be soluble.

The coatings on cloth for making artificial leathers are produced in various colors. They are finished bright and dull, the treatment for obtaining the bright finish being the same as in finishing bright leather; that is, varnish is applied after the last coat and a bright finish thereby produced.

**Coating real leather.**—This industry started about 20 years ago. At that time a firm at Newark, N. J., which was coating a large amount of leathers, shipped several carloads of the coated hides to their customers, and when the users tried to unwrap the packages they could not be cut apart with an axe. The hides were ruined. This practically killed the use of pyroxylin on splits for a number of years, and only recently have the tanners been willing to run the chance, as they expressed it, of using pyroxylin instead of japan for finishing their hides or splits.

Improper coating was the cause of the hides sticking, or the introduction of some oil that should not have been employed with the pyroxylin. There are various oils even now used in the trade, such as boiled rape-seed oil or boiled linseed oil. It is believed by many that neither one of these oils should be used in a pyroxylin coating for the reason that linseed, being a drying oil, will cause the goods to crack; rapeseed oil is perhaps not so dangerous, and may last very well, but in any case there is a question, and most manufacturers are afraid to take a chance.

It is well known, however, that castor oil will stand almost indefinitely, as it is a non-drying oil. It is true that goods coated with pyroxylin to which castor oil has been added, if kept rolled up, will sometimes dry out and something happens to the oil, and the goods will crack, snapping almost like

a match. However, that does not often occur, and only when kept rolled up for a long time away from contact with the air. If these goods that have gone bad are again given one or two coatings of pyroxylin, they will become as soft and pliable and as tenacious as they were before.

In making a pyroxylin for the split leather trade, the solution used is considerably thinner than the ordinary solutions, because splits have to be coated by hand with a swab and the liquor cannot be spread as easily or as economically under these conditions. In split leathers, the common method for the first coat is to use a soft, heavy brush, 2½ in. wide and about 6 or 7 inches long, with a strap over it. This is dipped into the solution and passed evenly over the goods; the hides are hung on a pole, preferably in a warm room, free as possible from moisture, as this is the one element that gives the greatest trouble in working with solutions of pyroxylin.

For the first coat an 8 to 12-oz. solution is used. Splits often have a heavy nap on them, and a thin solution spread over will leave the nap standing; whereas a heavy solution without putting nearly as much on, will, as it were, cement the nap down. The heavier the solution the less solvent is required, a saving, as the solvent is simply a carrier.

For the first coat on such leather, therefore, it is well to use a 12-oz. solution. With this should be mixed for each gallon, 3½ lb. of oil, according to the softness of the leather desired. The usual run of split leather is employed for ordinary carriage cushions, upholstery, etc. The color of most of the hides coated with pyroxylin is black, this color requiring 2 lb. of dye to about 50 gallons of the solution. Pigments can be used, but as few tanners have proper mills for grinding them, dyes are more commonly used. An advantage in dyes is that they remain in solution almost indefinitely, whereas when pyroxylin is mixed with pigment it is necessary to keep stirring continually to prevent the pigment from settling out.

Having prepared a 12-oz. cotton solution to which 3 lb. of castor oil and 2 or 3 oz. of a soluble dye has been added for each gallon, it is spread over the goods in a warm, moisture-

free room. About 3 lb. of this solution is required as the first coat on a 50-foot split. A change is made in the second coat, in order to keep the oil away from the surface. If the same amount of oil were used in the second coat as in the first, the goods would dry out sticky, and with very little heat it would fry out and the color would be spoiled. The second coat is made up with about half the amount of oil as in the first coat. As a rule, a 10-oz. cotton is used, to which is added 2 lb. of oil, the object being to smooth off the stock with the least amount of material. About 2 lb. of this solution is required for each 50-foot split. The hide is hung up to dry, and the third coat consisting of a 12-oz. cotton, to which 6 oz. of oil is added, is applied. When it is desired to produce a better grade or a brighter finish a fourth coat is spread on the hide.

Having applied the necessary number of bottom coats the goods are embossed with any design of grain desired.

To obtain a bright finish, the goods, after embossing, are recoated with a very thin solution of pyroxylin, say about 2 oz. to the gallon. Care should be taken that it contains the full amount of amyl-acetate or a substitute to keep it from having any tendency to become whitish, as even a black color has a tendency to show a grayish tinge if this precaution is not observed. This thin coat is generally applied with a sheepskin swab tacked over a board about the size of the brush, say 2½ by 6 inches. Bright finishes may also be improved by giving a final coat of linseed-oil varnish.

To make a dull shade, take a solution of pyroxylin, practically 2 oz. to the gallon, and add 4, 5, or 6 oz. of ground pigment to it. To be in proper condition this pigment must be ground in some oil medium. For artificial leather, tons of pigments are ground in castor oil. There is an objection to the use of castor for the top coat, as it does not give as dull a finish as it would if the color were added without any oil. The material best suited for dull finish is crude birch tar oil. It is made from the birch tree, and has somewhat the odor of wintergreen oil. It can be purchased in the wholesale

market at 10 or 12 cents per lb., whereas the refined birch oil costs more than that per ounce.

The crude is perhaps better than the refined oil on account of the fact that in grinding it has less tendency to evaporate. If not used in too large quantities this also gives a pleasant odor to the leather. The amyl-acetate odor for leather is rather objectionable, as even the most refined will leave behind an amyl or fusel oil odor for a long time, even for years, if the goods are not exposed to the air.

# CHAPTER XXI

## ANALYTICAL METHODS *

**Water analysis.**—It is quite evident that chemical control of the tannery should start with an analysis of the water that is to be used in practically every operation which the hides undergo while being made into leather. According to Procter, the most important determinations are total solids, ash, organic matter, sulphates, chlorides, iron, temporary hardness, permanent hardness, magnesia hardness, free carbonic acid, and sodium carbonate.

As a general statement, the purer the water the better it is suited for use in the tannery. It is evident, therefore, that the lower the total solids and ash the better for this purpose. Organic matter is liable to be accompanied by putrefactive bacteria, the action of which might cause serious damage to the hides or skins in all the beam-house operations up to the actual tanning process. Sulphates and chlorides to some extent tend to prevent the necessary swelling of the heavier leathers in the tanning liquors. Also, if present in large quantities, they interfere with the extraction of tanning material; for example, water containing a large amount of chlorides has been found to cause a considerable loss of tannin in the case of oak bark, pine bark, and sumac. Iron would unite with the tannins, forming bad stains, and would thus make the water unsuitable in all cases except where only black leather is to be made. Hardness in general is objectionable, temporary being more so than permanent. Temporary hardness slows up the soaking process, decreases the efficiency of sodium sulphide solution as a depilant, interferes with de-liming due to the formation of $CaCO_3$ in the hide, and causes loss of tannin in the leaching and tanning process. Owing probably to its alkalinity,

*Many of the methods given in this chapter were compiled by Ernest Little while instructor in chemistry at Pratt Institute, Brooklyn, N. Y.

calcium carbonate causes oxidation of the tannin and consequent darkening of the leather. It will react with the fat-liquor, precipitating insoluble calcium and magnesium soaps, as well as precipitating some of the aniline dyes. The action of temporary hardness in forming boiler scale is well known.

Permanent hardness is as objectionable in boiler water as temporary hardness. It would act the same as the latter in the fat-liquors, but will cause a much smaller loss of tannins and dyestuffs. Carbonic acid and sodium carbonate would cause $CaCO_3$ to be precipitated in the hide during the deliming process. Sodium carbonate, like other alkaline salts, will cause oxidation of vegetable tanning liquors with a consequent bad color.

*Total solids.*—100 cc. of sample is evaporated to dryness in a weighed platinum dish on a water-bath, then dried to constant weight at 100° C., cooled in a desiccator, and weighed. Increase in weight × 1000 = parts total solids per 100,000 parts of water.

*Ash.*—The above residue is ignited until the ash is white and weight is constant, cooling the dish in desiccator as usual, before weighing. Weight of dish + ash — weight of dish = grams of ash. Grams of ash × 1000 = parts per 100,000.

*Organic matter.*—Moisten the ash in the platinum dish with ammonium carbonate solution. This solution is then evaporated to dryness, dried at 100° C., and weighed. This weight, subtracted from the weight of the dish + total solids, gives the weight of organic matter in the sample, then grams of organic matter × 1000 = parts per 100,000.

The ammonium carbonate solution is added in order to correct for any carbonates which may have been decomposed by overheating.

*Sulphates.*—250 cc. of filtered sample is acidified with 2 cc. of concentrated hydrochloric acid. The solution is heated to boiling, and 15 cc. of 10 per cent barium chloride solution is added very slowly with constant stirring. Boil the solution

gently for 10 minutes, allow the solution to stand about 30 minutes, filter, wash thoroughly with hot distilled water, ignite, and weigh. Weight of $BaSO_4 \times 0.342 \times 400$ = parts of $SO_3$ per 100,000.

*Chlorides.*—100 cc. of sample is placed in a small porcelain casserole and 2 drops of potassium chromate solution (free from chlorides) added. Run in N/10 silver nitrate solution (4.25 grams $AgNO_3$ per 250 cc.) from a burette until one drop causes a permanent red-brown tinge in the solution, then, cc. N/10 $AgNO_3$ solution used $\times$ 0.00355 $\times$ 1000 = parts of chlorine per 100,000.

*Iron.*—500 cc. of sample is made acid with sulphuric acid, and evaporated to dryness in a porcelain casserole. Add a few drops of concentrated nitric acid and ignite gently until all organic matter is destroyed. Warm the residue with 15 cc. distilled water and 5 cc. 1 : 1 HCl, and wash the filter-paper thoroughly. Add dilute potassium permanganate solution drop by drop until slight pink color remains 5 minutes. Avoid adding too much dilute potassium permanganate solution. To this colorless solution add 10 cc. of 2 per cent potassium sulphocyanide, put in Nessler tube and dilute to 100 cc. and stir thoroughly. Into a second Nessler tube add 15 cc. of distilled water, 5 cc. 1 : 1 hydrochloric acid, then treat with dilute potassium permanganate and potassium sulphocyanide exactly as above, dilute to a little less than 100 cc. (about 99.5 cc.) and add standard iron solution drop by drop until in the well-mixed solution is the same depth of color as in the first tube.

The iron solution is made by dissolving 0.1 gram of pure iron wire in a little dilute hydrochloric acid, to which a few drops of concentrated nitric acid have been added. This solution is then diluted to 1000 cc., and 1 cc. of solution = 0.0001 gram of iron.

*Temporary hardness.*—200 cc. of sample is titrated with N/10 acid until faint pink color appears, using methyl-orange as an indicator. 1 cc. N/10 acid = 0.005 gram $CaCO_3$; report parts per 100,000. N/50 acid will give a better titration.

1 cc. N/50 acid = 0.001 gram $CaCO_3$. If N/50 acid is used, 100 cc. of sample should be titrated.

(Note: If alkaline hardness is present, the amount of N/10 acid necessary to neutralize it should be subtracted from the above volume of N/10 acid before temporary hardness is calculated.)

*Permanent hardness.*—Measure 200 cc. of sample into a porcelain casserole, boil to expel $CO_2$, add 25 cc. of N/10 sodium hydroxide, and evaporate to about 50 cc. Cool, filter, wash the filter-paper thoroughly, dilute the filtrate to about 100 cc., add a few drops of methyl-orange, titrate to faint pink, point with N/10 acid.

The number of cubic centimeters of N/10 acid used, subtracted from 25 = cc. of N/10 acid, corresponding to permanent hardness in 200 cc. of water.

1 cc. of N/10 acid = 0.005 gram $CaCO_3$. Report permanent hardness as parts of $CaCO_3$ per 100,000.

*Magnesia hardness.*—This is calculated as follows: remove temporary hardness from 100 cc. sample with N/10 acid, as described above. Boil to about 85 cc. to expel all $CO_2$. Transfer to 200 cc. glass-stoppered graduated flask; add 100 cc. of lime water, the value of which is known in terms of N/10 acid. Heat nearly to boiling; cool, and make up to mark with boiled distilled water. Pipette off 100 cc. of clear supernatant liquid, and titrate with N/10 acid, using phenolphthalein as an indicator; then cc. of N/10 acid necessary to neutralize 50 cc. lime water — cc. N/10 acid used in final titration = cc. N/10 acid corresponding to magnesia hardness in 50 cc. sample. 1 cc. N/10 acid = 0.005 gram $MgCO_3$. Report magnesia hardness as parts of $MgCO_3$ per 100,000.

*Free carbonic acid.*—100 cc. sample are titrated with N/10 sodium carbonate, using phenolphthalein as indicator. When all of the carbonic acid has been converted to $NaHCO_3$ by the $Na_2CO_3$, and there is slightest excess of $Na_2CO_3$, the solution will turn pink.

*Alkaline carbonates.*—In the determination of permanent

hardness, if the alkali found by the final titration is in excess of the alkali added, this excess is due to alkaline carbonates, and should be calculated as $Na_2CO_3$.

Cc. N/10 acid used in titration — cc. N/10 alkali added = cc. N/10 corresponding to alkaline carbonates in 200 cc. of sample. 1 cc. N/10 acid = 0.0053 gram $Na_2CO_3$. Report alkaline carbonates as parts of $Na_2CO_3$ per 100,000.

**Soaks.**—The only determination of any importance in the analysis of soak water is that of hide substance, this being a measure of the extent to which the hides are being decomposed.

*Stiasny's method.*—200 cc. of soak water is poured into a 250 cc. graduated flask; 20 cc. of a 5 per cent solution of zinc sulphate is now added, and the solution made up to the mark. Allow the solution to stand 5 minutes and filter through a 15 cc. pleated filter. Titrate 50 cc. of filtrate, as a blank, against N/10 sodium hydroxide, using phenolphthalein as an indicator. To another 50 cc. portion add 10 cc. of 40 per cent formaldehyde, which has been treated with pure barium carbonate, and titrate as above. The difference in the two burette readings is due to the amino acids which are formed by the decomposition of the hide substance. These acids condense with the formaldehyde, forming methylen-amino acids, which give a good titration and a sharp end-point when phenolphthalein is used as an indicator.

$$\frac{\text{cc. N/10 NaOH} \times 0.00786 \times 25 \times 3.785}{453.6} = \text{pounds of hide substance per gallon}$$

or

$$\text{cc. N/10 NaOH} \times 0.00164 = \text{pounds of hide substance per gallon.}$$

The hide substance in soak water can be more accurately determined by the Kjeldahl method, but the above procedure is much quicker and more satisfactory for control.

**Lime.**—The most important determination in the analysis of lime is that of available lime. The determination of iron, calcium, magnesium, and alkalinity of a saturated solution may also be of great importance in individual cases. As a

general statement, a good lime should contain about 90 to 95 per cent available CaO. The presence of MgO in quantities greater than 2 per cent is objectionable, owing to the fact that improper slaking may result and the hides may be burned by the small lumps of CaO. The objections to iron in any but small traces are well known.

*Available lime.*—Weigh 1 gram of a uniform sample and transfer it to a 1-liter graduated flask. The flask is then filled to the mark with well-boiled hot water. The flask is stoppered at once and shaken frequently during the next few hours to ensure complete solution of the lime. When the solution is cold, it is again made up to the mark, shaken, and allowed to settle; then 50 cc. of the clear liquid is pipetted off and titrated with N/10 hydrochloric acid, using phenolphthalein as an indicator.

$$\frac{\text{cc. N/10 HCl} \times 20 \times 0.0028 \times 100}{\text{weight of sample}} = \text{available CaO.}$$

*Iron, calcium, and magnesium.*—A 5-gram sample is weighed into a porcelain dish, and 25 cc. of concentrated hydrochloric acid is added. Cover dish with a watch-glass and boil until solution is complete. Rinse off the watch-glass and evaporate to dryness on the water-bath. The residue is treated with dilute hydrochloric acid and filtered into a 250 cc. graduated flask. Wash the filter-paper thoroughly. Cool the filtrate, make up to mark and mix well; 25 cc. of this solution are taken and Fe, Ca, and Mg are determined by the usual analysis. The Fe being precipitated by $NH_4Cl + NH_4OH$ in hot solution, the calcium is precipitated as $CaC_2O_4$ in a weak $NH_4OH$ solution; and magnesium is precipitated as $MgNH_4PO_4$ in a faintly ammoniacal solution, then one-third of its volume of concentrated $NH_4OH$ is added, and the solution is allowed to stand over night before filtering. Re-precipitation is necessary in each operation.

The iron can also be determined by taking 25 cc. of the above solution, making acid with nitric acid, boiling a few minutes, and transferring to a 100 cc. graduated flask; make

up to mark and determine iron colorimetrically with potassium sulphocyanide as outlined under water analysis.

*Alkalinity of saturated solution.*—This determination is of importance owing to the fact that an impure lime may possibly show greater alkalinity than a pure one, as the impurities may react with the lime to form more soluble bases than $Ca(OH)_2$.

One gram of lime is shaken thoroughly with 100 cc. of water, and the method proceeded with as in the determination of available lime. [50 cc. of a saturated solution of pure lime at room temperature (15° C.) will neutralize 23.6 cc. of N/10 HCl.] If more hydrochloric acid than this is required it will be for the reasons given above.

**Sodium sulphide.**—Commercial sodium sulphide is usually obtained either in the crystalline form or fused. The first form has the formula $Na_2S.9H_2O$, and contains about 32.5 per cent $Na_2S$; the other salt contains less water and about 60 per cent $Na_2S$. The most common impurities of sodium sulphide are $Na_2CO_3$, $Na_2SO_4$, $Na_2S_2O_3$, NaOH, and polysulphides.

The percentage of $Na_2S.9H_2O$ (or sulphide sulphur) and the NaOH in the sodium sulphide are the determinations usually made.

*$Na_2S.9H_2O$.*—Twelve grams of the sample is dissolved in water and made up to 1000 cc; 10 cc. of this solution are pipetted into a 200 cc. beaker, diluted to about 100 cc., and titrated at once with an N/10 zinc sulphate solution until one drop gives no dark turbidity with nickel sulphate (or purple color with sodium nitro-prusside) used as an outside indicator.

The zinc sulphate solution is made by dissolving 3.27 grams of c.p. zinc in dilute hydrochloric acid (the zinc being in contact with a piece of clean platinum), then adding an excess of ammonium hydroxide, 50 grams of ammonium chloride, and making up to one liter. Or, dissolve 14.35 grams of pure $ZnSO_4.7H_2O$ in water, add $NH_4OH$ until the precipitated $Zn(OH)_2$ re-dissolves, add 50 grams of $NH_4Cl$, and make up to one liter.

$$\text{Percentage of } Na_2S.9H_2O = \frac{\text{cc. N/10 } ZnSO_4 \text{ sol.} \times 100 \times 0.012 \times 100}{\text{weight of sample}}$$

or

$$\text{Percentage of } Na_2S = \frac{\text{cc. N/10 } ZnSO_4 \text{ sol.} \times 100 \times 0.0039 \times 100}{\text{weight of sample}}$$

Polysulphides, sulphates, or thiosulphate are not included in this determination, only those sulphides which would yield hydrogen sulphide and hydrochloric acid.

*Total alkalinity and NaOH in the $Na_2S$.*—Pipette 50 cc. of the above solution into a 200 cc. beaker, dilute to 100 cc., and titrate with N/10 hydrochloric acid, using methyl-orange as an indicator. This gives total alkalinity. The sodium hydroxide in the $Na_2S.9H_2O$ can be calculated as follows:

$$\text{Percentage of NaOH} = \frac{\text{cc. N/10 HCl} - 5(\text{cc. N/10 } ZnSO_4 \text{ sol.}) \times 20 \times 0.004}{\text{weight of sample}}$$

When $Na_2S$ is dissolved in water it is hydrolyzed considerably into NaOH + NaSH, as shown in the equation

$$Na_2S + H_2O = NaOH + NaSH$$

Both of these products of hydrolysis, as well as the non-hydrolyzed $Na_2S$, react with the N/10 HCl.

$$\begin{aligned} &(1)\ NaOH + HCl = NaCl + H_2O \\ &(2)\ NaSH + HCl = NaCl + H_2S \\ &(3)\ Na_2S + 2HCl = 2NaCl + H_2S \end{aligned}$$

Any free NaOH originally present in the sample will also react according to equation (1). Therefore the number of cubic centimeters of N/10 hydrochloric acid used in this tritration were used in reacting with $Na_2S$, NaSH, and NaOH formed by hydrolysis and NaOH originally present as such. Therefore the cc. of N/10 zinc sulphate solution necessary, subtracted from cc. of N/10 HCl for the same size sample, gives the cc. of N/10 HCl necessary to neutralize the free NaOH. This may be clearer if we look at the problem in this way: The number of cc. of N/10 zinc sulphate solution is the same as it would have been had there been no hydrol-

ysis. This number of cc. of N/10 zinc sulphate solution is exactly equal to the number of cc. of N/10 acid necessary to react with $Na_2S$, NaSH, and NaOH formed by hydrolysis. Therefore, the cc. of N/10 zinc sulphate solution subtracted from the cc. of N/10 acid used in the determination of total alkalinity gives the cc. of N/10 acid necessary to neutralize the free NaOH. Methyl-orange is not sensitive to $H_2S$, so it does not interfere with the titration.

**Analysis of arsenic sulphide.**—Red arsenic is composed chiefly of $As_2S_2$, with some $As_2S_3$, and containing $As_2O_3$ and free sulphur as impurities. These substances are useless as depilating agents, only sulphide sulphur being available for this purpose. For a complete analysis, determine the percentage of arsenic and the amount of soluble sulphides produced by the action of sodium hydroxide on the sample.

*Arsenic.*—5 grams of the powdered sample are weighed in a beaker and boiled with concentrated nitric acid, covering the beaker with a watch glass. This nitric acid treatment dissolves the arsenic and oxidizes it to $H_3AsO_4$. When solution is complete, evaporate off most of the acid on the water-bath, dilute, and filter. To the filtrate add an excess of ammonium hydroxide and about 20 cc. of clear magnesia mixture. Allow it to stand 24 hours, filter, and wash with 3 per cent ammonia water. Dry the $MgNH_4AsO_4$ and separate from the filter-paper. The paper is ignited in a weighed porcelain (not platinum) crucible. The precipitate is then added to the same crucible and the whole gradually heated to a red heat, which is maintained for 10 minutes. The $Mg_2As_2O_7$ in the crucible is now weighed, and the weight of the empty crucible subtracted.

$$\text{Percentage of } As_2S_2 = \frac{\text{grams } Mg_2As_2O_7 \times 0.6985 \times 100}{\text{weight of sample}}$$

*Sulphide sulphur (Procter's method.)*—One gram of the sample is digested for 3 hours with 50 cc. of 10 per cent sodium hydroxide solution, with frequent shaking. Make up

to 100 cc. with distilled water and filter; 50 cc. of the filtrate is titrated with N/10 zinc sulphate solution as described under analysis for sodium sulphide.

Percentage of active sulphur =

$$\text{cc. N/10 } ZnSO_4 \text{ sol.} \times 2 \times 0.0016 \times 100$$

or

$$\text{Percentage of active sulphur} = \text{cc. N/10 } ZnSO_4 \text{ sol.} \times 0.32$$

**Lime liquors.**—The most important determination in the analysis of limes is that of hide substance. Too high a hide substance content indicates putrid limes and loss of stock. Soluble lime, available lime, and $CaCO_3$ are also factors that are sometimes useful.

*Soluble lime and hide substance.*—The sample of lime liquor (which has been collected after thorough plunging of the limes) is well shaken and carefully mixed. About 100 cc. of this liquor is filtered at once through a dry filter-paper into a clean, dry beaker; 50 cc. of this filtrate is pipetted into a 500 cc. graduated flask and diluted to the mark with water free from $CO_2$. Difficulty is often experienced in filtering this lime liquor. Colloidal hide substance will fill up the pores of the filter-paper and make filtration a very slow process. Also finely divided particles of lime sometimes pass through the filter-paper, giving a cloudy filtrate. Under these conditions it is better to allow the lime liquor to stand over night in a stoppered bottle, then filter the clearer upper portion of the lime liquor through a dry paper. This filtrate is well mixed, 100 cc. are pipetted off and titrated with N/10 acid, using phenolphthalein as an indicator. When the phenolphthalein end-point has been reached, add a couple drops of methyl-orange and then add N/10 hydrochloric acid, drop by drop, until solution turns pink.

Percentage of soluble $Ca(OH)_2$ =

$$\frac{\text{cc. N/10 phenolphthalein} \times 0.0037 \times 100}{10}$$

The amount of acid used after reaching the phenolphthalein end-point until the methyl-orange end-point is reached

is a rough measure of the hide substance present. This is due to the fact that the calcium salts of many of the products of decomposition of hide substance, as albuminates, and amino acids, do not change methyl-orange, although they do destroy the pink color of the salt of phenolphthalein. Approximately 0.0053 gram of hide substance when in solution would in this way furnish enough alkalinity to neutralize 1 cc. of N/10 acid; therefore,

$$\text{Percentage of hide substance} = \frac{\text{cc N/10 HCl (m.o.)} \times 0.0053 \times 100}{10}$$

Ten cubic centimeters of a saturated solution of pure $Ca(OH)_2$ will neutralize 4.72 cc. of N/10 HCl. If more than this amount of HCl is used in the above titration (phenolphthalein + methyl-orange together) the reason is the presence of $NH_3$ resulting from the decomposition of the hide or to added salts reacting with the lime to form other alkalies.

Two other more accurate methods of determining hide substance in lime liquors are taken up later.

*Available lime and $CaCO_3$.*—Available lime constitutes the dissolved lime and the lime not in solution; $CaCO_3$ is usually present in small amount and is not of great importance of itself, but it must be considered in order to get an accurate determination of available lime.

The sample is thoroughly mixed, and 10 cc. of unfiltered liquor are pipetted out, washed into a liter flask with water free from $CO_2$, and diluted to the mark; 100 cc. of this solution (1 cc. of original lime liquor) are measured into a 200 cc. beaker and titrated with N/10 HCl, using first phenolphthalein and then completing the titration with methyl-orange as an indicator.

(a) cc. N/10 HCl used for the phenolphthalein titration were used in neutralizing all the available $Ca(OH)_2 + \frac{1}{2}CaCO_3$ present.

(b) cc. N/10 HCl used for the methyl-orange titration were used in neutralizing $\frac{1}{2}CaCO_3$ + hide substance.

(c) Therefore from (b) we get cc. of N/10 HCl necessary

to neutralize $\frac{1}{2}CaCO_3$ = cc. of N/10 HCl used in above methyl-orange titration, — 1/10 the number of cc. of N/10 HCl found necessary to react with the hide substance in the above determination of soluble lime and hide substance. Therefore:

Percentage of $CaCO_3$ =

$$2 \times \text{cc. N/10 HCl for } \tfrac{1}{2}\, CaCO_3 \times 0.005 \times 100$$

From (a) we get—cc. N/10 HCl to neutralize available $Ca(OH)_2$=cc. N/10 HCl used in the above phenolphthalein titration—cc. N/10 HCl necessary to neutralize $\frac{1}{2}$ $CaCO_3$. [This was found in (c).]

Therefore the percentage of available $Ca(OH)_2$=cc. N/10 HCl used in the above determination — cc. N/10 HCl necessary to neutralize $\frac{1}{2}CaCO_3$ [found in (c)] × 0.0037 × 100.

*Hide substance continued.*—The following approximate method may be of some use for control work. The chemistry involved is that the amino acids do not affect phenolphthalein, but when treated with formaldehyde they are converted into more strongly acidic compounds which can be titrated with N/10 NaOH, using phenolphthalein as an indicator.

Twenty-five cubic centimeters of filtered lime liquor is just neutralized with N/10 acid and a faint pink color (using phenolphthalein as an indicator) produced with a couple of drops of N/10 NaOH; 10 cc. of 40 per cent formaldehyde (neutral to phenolphthalein) is now added, and the solution titrated with N/10 sodium hydroxide.

No accurate factor is known to convert this reading into hide substance, but the cc. of N/10 acid used may be of value in comparing the relative amounts of the products of decomposition of hide substance in different limes.

*Kjeldahl method for hide substance.*—Filter a sample of the lime liquor to remove hairs or other suspended particles containing nitrogen. Pipette about 150 cc. of this filtrate into a Kjeldahl flask, and boil gently until the volume is reduced to a few cubic centimeters. Thirty cubic centimeters

of concentrated sulphuric acid and 15 grams of potassium sulphate, together with about three glass beads are now added and the solution, heated gently at first, is then boiled until all organic matter is destroyed and the solution is colorless. Cool and pour slowly with stirring into 100 cc. cold water. Transfer this to a 200 cc. graduated flask, rinsing out the beaker thoroughly and make up to mark with distilled water. Pipette out 50 cc., transfer to Kjeldahl flask, dilute to 100 cc. and make the solution strongly alkaline with a saturated solution of sodium hydroxide. Connect to a straight condenser by means of a Hopkins distilling head, and distill for about an hour. The distillate is caught in an Erlenmeyer flask containing 50 cc. of N/10 HCl + 2 drops methyl-orange. The end of the delivery tube extends below the surface of the acid. After about 75 to 100 cc. have distilled over, distillation is stopped, and the condenser and delivery tube are carefully rinsed with distilled water. The acid is now titrated with N/10 NaOH in order to determine the amount of acid not neutralized by the ammonia.

1 cc. N/10 acid = 0.0014 gram of nitrogen or 0.00786 gram of hide substance; 5.62 grams of dry hide substance = 1 gram of nitrogen.

$$\text{Percentage of hide substance} = \frac{\text{cc. N/10 acid} \times 0.00786 \times 100}{37.5}$$

or

$$\text{Percentage of hide substance} = \text{cc. N/10 acid} \times 0.02096$$

**Sulphide lime liquors:** *Sodium sulphide.*—50 cc. of filtered liquor is pipetted off, diluted to about 150 cc., and titrated with N/10 zinc sulphate solution as described under analysis of sodium sulphide.

$$\text{Percentage of } Na_2S = \frac{\text{cc. N/10 } ZnSO_4 \text{ sol.} \times 0.0039 \times 100}{50}$$

or

$$\text{Percentage of } Na_2S.\,9H_2O = \frac{\text{cc. N/10 } ZnSO_4 \text{ sol.} \times 0.012 \times 100}{50}$$

The following is a good method, but is much longer than the method given above. The sample is filtered, and 25 cc. of the filtrate is pipetted into a 200 cc. beaker; 25 cc. of 5 per cent cadmium chloride and 15 cc. of acetic acid are added, and the solution is boiled and filtered. Wash the precipitate with hot water, dissolve in dilute hydrochloric acid, and titrate with N/10 iodine solution using starch as an indicator.

$$\text{Percentage of } Na_2S = \frac{\text{cc. N/10 iodine} \times 0.0039 \times 100}{25}$$

or

$$\text{Percentage of } Na_2S.9H_2O = \frac{\text{cc. N/10 iodine} \times 0.012 \times 100}{25}$$

*Soluble lime and hide substance.*—The analysis is carried out exactly as that indicated under lime liquor. In this case the phenolphthalein end-point gives not only the dissolved alkalies, but also half of the $Na_2S$ due to its hydrolysis: $Na_2S + H_2O = NaOH + NaHS$.

Percentage of soluble $Ca(OH)_2$ =

$$\frac{\text{cc. N/10 HCl} - \tfrac{1}{2}\text{ cc. N/10 } ZnSO_4 \text{ sol.} \times 0.0037 \times 100}{10}$$

The cc. of N/10 acid used after reaching phenolphthalein end-point to the methyl-orange end-point are used in neutralizing the calcium salts of the decomposition products of the hide (so-called dissolved hide substance) + half of the $Na_2S$ present.

Percentage of hide substance =

$$\frac{\text{cc. N/10 HCl(m.o.)} - \tfrac{1}{2}\text{c.c. N/10 } ZnSO_4 \text{ sol.} \times 0.0053 \times 100}{10}$$

The above method for hide substance determination is only approximate and should not be relied on when the Kjeldahl method can be made. The latter method is run exactly as outlined under lime liquors, and is much more dependable.

In running the formaldehyde method for hide substance, the sulphides must first be oxidized to S, otherwise they will

react with the formaldehyde, forming compounds which greatly increase the alkalinity of the solution. The method as outlined by Stiasny is given below:

The liquor is filtered, 50 cc. pipetted into a beaker, diluted to 150 cc., and two drops of phenolphthalein added. Make slightly acid with acetic acid, and add N/10 iodine in slight excess. Titrate with N/10 NaOH until the solution becomes pink, then add 10 cc. of neutral 40 per cent HCHO; add N/10 NaOH until the phenolphthalein end-point appears. The cc. of N/10 NaOH used in this last titration is a measure of the amino acids in solution.

*Available lime and $CaCO_3$.*—The method can be run exactly as outlined under lime liquors. Here the phenolphthalein end-point will give available $Ca(OH)_2 + \frac{1}{2}CaCO_3 + \frac{1}{2}Na_2S$. Therefore, subtract from the total number of cc. of N/10 acid used, half the number of cc. of N/10 zinc sulphate solution used for the same size sample, and proceed with the calculation of available lime as outlined under lime liquors.

The cc. of N/10 HCl used after reaching the phenolphthalein end-point until the methyl-orange end-point is reached are used up in neutralizing $\frac{1}{2}CaCO_3$ + hide substance + $\frac{1}{2}Na_2S$. Therefore, subtract from the total number of cc. of N/10 acid used, half the number of cc. of N/10 zinc sulphate solution used for the same size sample, and proceed with the calculations of $CaCO_3$ as outlined under lime liquors.

**De-liming test.**—In de-liming limed hides and skins by means of acids it is customary to determine the completion of the process by applying a solution of phenolphthalein to a freshly cut section of the pelt. If such a solution is applied to a limed pelt, the section shows red; if to a completely de-limed pelt, there is no change of color. A partly de-limed pelt will show red in the middle and colorless on either side. Most tanners usually allow the de-liming to proceed to a given point. For some purposes complete de-liming is necessary, while for others a mere surface de-liming is sufficient, the

depth depending upon the nature of the subsequent tanning process. For example, if it is a question of sheepskins which are first de-limed with acid, then bated or puered, the first actual acid de-liming is usually carried out only to such an extent that a streak of free lime is left in the middle. With heavier goods, such as sole leather, the extent of the acid de-liming depends upon the nature of the liquors into which the goods are next placed. If the tail suspension liquors are very acid in character, it is not as important to neutralize as much lime as if these liquors were only slightly acid. The phenolphthalein test can be applied with almost any acid, but there is one caution that might be mentioned in its use, and that is that its action is more qualitative than quantitative. A trace of lime will give as strong a coloration as a large quantity of free lime, and cases have been known where this has led to confusion. To make the matter clear, it may be well to take a definite example:

Suppose that fully limed sole butts are being de-limed with one of the ordinary acids, and that the amount of acid present in the liquor is not quite sufficient to neutralize the whole of the lime; at the beginning of the process the whole section will show red on application of phenolphthalein, and after a short time the cut section will show red in the middle and colorless at the outsides. The depth of the outside strips will increase as the process goes on, until almost the whole of the acid has been neutralized by the free lime in the hides. When this point has been reached there will be a minimum red section in the center, but afterwards the free lime in the center will gradually diffuse out to the extremities, and so, on application of phenolphthalein, the whole section will show red. In this way it is possible for an almost completely de-limed hide to appear as though it were not de-limed at all. It is in this sense that the test is qualitative rather than quantitative. By taking cut sections at different stages of the process, and not only at the end, it is possible to determine exactly the actual extent of the de-liming.

**Salt.**—For moisture determination dry 5 grams of the sam-

ple in a tared dish at 100° C., over night. Weigh the loss in weight as water.

*Calcium oxide* (*CaO*).—Pipette 50 cc. of a solution made from 25 grams of the sample in 250 cc. water, into a 250 cc. beaker, make alkaline with ammonia, and bring to a boil on hot plate. Add an excess of ammonium oxalate and digest the solution for a half-hour. Filter the precipitate, and wash free from chlorides. Ignite, blast, cool, and weigh quickly as CaO.

*Sulphates* ($SO_3$).—Dilute 50 cc. of the above solution to about 100 cc., acidify with HCl, bring to a boil on a hot plate, and precipitate the sulphates with barium chloride. Digest for a half-hour, filter, and wash free from chlorides. Ignite, cool and weigh as $BaSO_4$. Calculate to $SO_3$. Test for traces of iron and magnesium. The NaCl is found by difference.

**Aluminum sulphate.**—Weigh out 6 grams of the pulverized sample, dissolve in water, and dilute to 250 cc.

*Aluminum oxide* ($Al_2O_3$).—Pipette 25 cc. of the above solution into a 250 cc. beaker, add 2 cc. of concentrated hydrochloric acid, dilute to about 100 cc., and bring to boil. Precipitate the aluminum from the boiling solution with a slight excess of ammonia. Boil until the solution smells but faintly of ammonia, filter, wash the precipitate, and ignite. Blast the precipitate, cool, and weigh, and repeat until the weight is constant. Calculate as $Al_2O_3$.

(Note:—If iron is present in the sample, the amount found under $Fe_2O_3$ must be subtracted from the precipitate.)

*Total sulphuric acid* ($H_2SO_4$).—Pipette 25 cc. of above solution into a porcelain casserole, dilute with about 150 cc. of water, and add a little phenolphthalein. Run in N/10 NaOH till the pink color remains on stirring. Heat and boil for one minute. Run in more N/10 NaOH and repeat the boiling, finally titrating to the end-point. This determination gives the sulphuric acid combined with the aluminum and any free acid present.

*Free sulphuric acid* ($H_2SO_4$).—From the two above determinations, the sulphuric acid necessary to form the normal

salt may be calculated. Formula: $Al_2(SO_4)_3.18H_2O$. Any excess of acid is figured as free sulphuric acid.

*Ferric oxide* ($Fe_2O_3$).—The sample should be tested for iron with potassium sulphocyanide. If present, proceed as follows: Weigh 25 to 50 grams, according to the amount of iron present, into a large Jena flask. Dissolve in about 500 cc. of water and make strongly acid with sulphuric acid. Add 5 grams of powdered zinc and heat on the steam bath till the action ceases, then test for ferric iron with $K_4Fe(CN)_6$. If the zinc contains iron, a blank must be run. Remove the flask from the bath if the iron is reduced, filter quickly, cool, and titrate with standard potassium permanganate.

**Pickle.**—The reagents are as follows:

Sodium hydroxide: N/10 solution, 1 cc. = 0.0049 gram $H_2SO_4$.

Silver nitrate: 2.9 grams per liter, 1 cc. = 0.001 gram NaCl.

Phenolphthalein: 1 gram per 100 cc. of alcohol.

Potassium chromate: 1 gram per 100 cc. of water.

*Sulphuric acid.*—Pipette 10 cc. of pickle into a 250 cc. casserole, to which add 100 cc. of water and 3 drops of phenolphthalein. Run in standard NaOH solution from burette with constant stirring until the liquid shows a faint pink color.

cc. N/10 NaOH $\times$ 0.0049 $\times$ 10 = x; x = grams of $H_2SO_4$ per 100 cc.

$$\frac{x \times 3785}{453.6 \times 100} \text{ or } x \times 0.0835 = y;\ y = \text{pounds of } H_2SO_4 \text{ per gallon.}$$

$$\frac{y}{0.935} = \text{pounds of commercial } H_2SO_4 \text{ per gallon.}$$

(Note:—3785 cc. = 1 gallon; 453.6 grams in 1 pound.)

*Sodium chloride.*—Dilute 10 cc. of pickle with water to 500 cc. in a 100 cc. graduated flask. Shake well and pipette 10 cc. into a 250 cc. casserole, then neutralize the acidity by a very slight excess of pure calcium carbonate. Then add five drops of potassium chromate solution and run in silver nitrate from burette, with constant stirring until the yellowish-white color changes to a slight reddish-brown.

cc. $AgNO_3 \times 0.001 \times 500 = x$; $x$ = grams of NaCl per 100 cc.

$$\frac{x \times 3785}{453.6 \times 100} \text{ or } x \times 0.835 = \text{pounds of NaCl per gallon.}$$

Some standard of concentration should be adopted in the preparation of pickle and 1 lb. of salt per gallon of water is a convenient strength. The ratio of sulphuric acid to sodium chloride should be 1 : 8; there should be therefore $\frac{1}{8}$ lb. or 2 oz. of sulphuric acid per gallon of pickle.

**Formaldehyde:** *Romijn's method.*—25 cc. of the dry formaldehyde solution is weighed accurately in a tared weighing bottle with a well-ground stopper, and washed without loss into a 500 cc. flask. The solution is made up to the mark, and 5 cc. is accurately measured into a bottle with a well-ground stopper; 30 cc. of N/1 NaOH, which need only be measured in a graduated cylinder, is added rapidly. About 50 cc. of N/5 iodine is immediately run in from a burette, with frequent shaking, until the liquid is deep yellow. The bottle is stoppered, well shaken for a half a minute, and the contents acidified with 40 cc. of N/1 sulphuric acid (measured in a graduated cylinder), and after a short time, during which the bottle is kept stoppered, the excess of iodine is titrated with N/10 sodium thiosulphate.

$$HCHO + I_2 + 2H_2O = HCOOH + 2HI.$$

Each cc. of N/5 iodine equals 0.003 grams of HCHO.

**Two-bath chrome liquors:** *Determination of Cr as $Cr_2O_3$, $Na_2Cr_2O_7$, or $Na_2CrO_4$.*—10 cc. of the liquor is placed in a 250 cc. graduated flask and diluted to the mark. After thorough mixing, 50 cc. is pipetted off and run into a 500 cc. beaker; 5 cc. of concentrated hydrochloric acid and 10 cc. of 10 per cent potassium iodine solution is now added. The solution is cooled, diluted to about 400 cc., allowed to stand a few minutes, and the liberated iodine titrated with N/10 $Na_2S_2O_3$ solution, using starch as an indicator. Do not add

the starch until the brown color of the iodine is nearly destroyed.

1 cc. of N/10 $Na_2S_2O_3$ equals 0.00333 gram $CrO_3$, or 0.00436 gram $Na_2Cr_2O_7$, or 0.0054 gram $Na_2CrO_4$.

Grams of $CrO_3$ per 100 cc. cc. N/10 $Na_2S_2O_3 \times 0.0033 \times 50$.

*Acidity.*—Take 10 cc. of liquor, dilute to 200 cc., and titrate with N/10 NaOH, using phenolphthalein as an indicator. The sodium hydroxide will be taken up by the $Na_2Cr_2O_7$, the $H_2Cr_2O_7$, and the free acid as HCl or $H_2SO_4$.

(*a*) *Assume bath is all $Na_2Cr_2O_7$.*—$\overset{(262)}{\overline{Na_2Cr_2O_7}} + 6KI + 14HCl \quad 2NaCl + 2CrCl_3 + 6KCl + 7H_2O + \overset{(762)}{\overline{3I_2}}$.

262 : 762 :: 1 : x; x = 2.908 grams of I liberated by 1 gram of $Na_2Cr_2O_7$. 1 cc. N/10 iodine solution contains 0.0127 gram. Iodine. $\frac{2.908}{0.0127} = 228.9$ cc. N/10 I solution could be formed from the iodine liberated by 1 gram of $Na_2Cr_2O_7$. Therefore, 228.9 cc. N/10 $Na_2S_2O_3$ will be required to absorb the iodine liberated by 1 gram of $Na_2Cr_2O_7$.

$$\underset{(262)}{Na_2Cr_2O_7} + 2\overset{(80)}{\overline{NaOH}} = 2Na_2CrO_4 + H_2O.$$

262 : 80 :: 1 : x; x = 0.3053 grams of NaOH necessary to react with 1 gram of $Na_2Cr_2O_7$.

1 cc. N/10 NaOH = 0.004 gram of NaOH.

Therefore, $\frac{0.3053}{0.004} = 76.3$ cc. N/10 NaOH for 1 gram $Na_2Cr_2O_7$. $\frac{228.9}{76.3} = 3$. When the bath is all $Na_2Cr_2O_7$ the cc. of N/10 NaOH = 1/3 cc. N/10 $Na_2S_2O_3$.

*Strength.*—cc. N/10 $Na_2S_2O_3 \times 0.00436 \times 50$ = grams $Na_2Cr_2O_7$ per 100 cc.

(Note: 0.00436 = grams $Na_2Cr_2O_7$ in 1 cc. N/10 solution. 262 (mol. wt.) $Na_2Cr_2O_7 \div 6 = 43.6$ grams of $Na_2Cr_2O_7$ in 1 liter of normal solution.)

(*b*) *Assume bath is a mixture of $Na_2Cr_2O_7$ and $Na_2CrO_4$.*—$Na_2CrO_4$ does not react with NaOH; therefore the cc. of N/10 NaOH = $\frac{1}{3}$ cc. N/10 $Na_2S_2O_3$.

*Strength.*—cc. N/10 NaOH × 0.0131 × 10 grams $Na_2Cr_2O_7$ in 100 cc. bath.

$$\frac{\overset{(262)}{Na_2Cr_2O_7}}{\underset{(104)}{2\ Cr}} = \frac{\text{grams } Na_2Cr_2O_7 \text{ in 100 cc}}{x}; \; x = \text{grams Cr in form}$$

of $Na_2Cr_2O_7$ in 100 cc. of bath.

cc. N/10 $Na_2S_2O_3$ × 0.00173 × 50 = x′ or total grams Cr in 100 cc. of bath.

x′—x = grams of chromium as $Na_2CrO_4$ in 100 cc. of bath.

(Note: 0.0131 = grams $Na_2Cr_2O_7$ in 1 cc. N/10 solution when $Na_2Cr_2O_7$ is acting as an acid to neutralize NaOH.)

262 (mol. wt.) $Na_2Cr_2O_7$ ÷ 2 = 131 grams $Na_2Cr_2O_7$ for 1 liter of normal solution; 0.00173 = grams Cr in 1 cc. N/10 solution when acting as an oxidizing agent.

52 (atomic weight of chromium) ÷ 3 = 17.3 grams Cr in 1 liter of solution.

(*c*) *Assume bath is all $H_2Cr_2O_7$.*—$\overset{(218)}{\overline{H_2Cr_2O_7}} + 6KI +$

$$12HCl = 2CrCl_3 + 6KCl + 7H_2O + \overset{(762)}{\overline{6I}}$$

218 : 762 : : 1 : x; x = 3.498 grams of I liberated by 1 gram of $H_2Cr_2O_7$.

$\frac{3.498}{0.0127}$ = 275.4 cc. N/10 $Na_2S_2O_3$ necessary to absorb the iodine liberated by 1 gram of [see explanation in (*a*)] $H_2Cr_2O_7$.

$$\overset{(218)}{\overline{H_2Cr_2O_7}} + \overset{(160)}{\overline{4NaOH}} = 2Na_2CrO_4 + 3H_2O.$$

218 : 160 :: 1 : x; x = 0.7339 gram NaOH necessary to react with 1 gram of $H_2Cr_2O_7$ ($H_2Cr_2O_7$ does not exist out of solution).

$\frac{0.7339}{0.004}$ = 183.5 cc. N/10 NaOH necessary to react with 1 gram of $H_2Cr_2O_7$.

183.5 is $\frac{2}{3}$ of 275.4, therefore when the bath is all $H_2Cr_2O_7$ the cc. of N/10 NaOH = $\frac{2}{3}$ cc. N/10 $Na_2S_2O_3$.

*Strength.*—cc. N/10 $Na_2S_2O_3 \times 0.00333 \times 50$ = grams $CrO_3$ (as $H_2Cr_2O_7$) per 100 cc. of solution.

(Note: 0.0033 = grams $CrO_3$ per cc. N/10 solution.)

100 (mol. wt.) $CrO_3 \div 3 = 33.3$ grams $CrO_3$ per liter of normal solution.

(*d*) *Assume bath is a mixture of $H_2Cr_2O_7$ and $Na_2Cr_2O_7$.*—Both of these react with the NaOH and $Na_2S_2O_3$. Then cc. N/10 NaOH = $\frac{2}{3}$ and $\frac{1}{3}$ cc. N/10 $Na_2S_2O_3$.

*Strength.*—

Let a = cc. N/10 $Na_2S_2O_3$ for $Na_2Cr_2O_7$ and $H_2Cr_2O_7$.
" b = " " " " " .
" c = " " " " $H_2Cr_2O_7$.

(1) Then b + c = a.

Let a′ = cc. N/10 NaOH for $Na_2Cr_2O_7$ and $H_2Cr_2O_7$.
" b′ = " " " " " .
" c′ = " " " " $H_2Cr_2O_7$.

(2) Then b′ + c′ = a′.

But $Na_2Cr_2O_7$ requires 3 times as many cc. of N/10 $Na_2S_2O_3$ as it does cc. of N/10 NaOH.

(3) Therefore, $b' = \frac{b}{3}$

Also $H_2Cr_2O_7$ requires $\frac{2}{3}$ as many cc. of N/10 NaOH as cc. of N/10 $Na_2S_2O_3$.

(4) Therefore, $c' = \frac{2c}{3}$

In equation (2) substitute (3) and (4), therefore

$\frac{b}{3} + \frac{2c}{3} = a'$ or

(5) $b + 2c = 3a'$

(6) From (1) we get $b = a - c$.

Substitute (6) in (5)

$a - c + 2c = 3a'$ or $a + c = 3a'$ or

$c = 3a' - a$. This gives cc. N/10 $Na_2S_2O_3$ used for $H_2Cr_2O_7$.

$a - c = b$ cc. N/10 $Na_2S_2O_3$ used for $Na_2Cr_2O_7$.

*Strength.*—cc. N/10 $Na_2S_2O_3$ (c) $\times$ 0.0033 $\times$ 50 = grams $CrO_3$ (as $H_2Cr_2O_7$) per 100 cc. of solution.

cc. N/10 $Na_2S_2O_3$ (b) $\times$ 0.00436 $\times$ 50 = grams $Na_2Cr_2O_7$ per 100 cc. of solution.

(*e*) *When bath contains free acid (HCl or $H_2SO_4$).*—Under these conditions all chromium will be in the form of $H_2Cr_2O_7$ and the cc. N/10 NaOH = $\frac{2}{3}$ cc. N/10 $Na_2S_2O_3$.

*Strength.*—cc. N/10 $Na_2S_2O_3$ $\times$ 0.0033 $\times$ 50 = grams $CrO_3$ as $H_2Cr_2O_7$ per 100 cc.

Since for $H_2Cr_2O_7$ the cc. N/10 NaOH = $\frac{2}{3}$ cc. N/10 $Na_2S_2O_3$.

Then, cc. N/10 NaOH — $\frac{2}{3}$ cc. N/10 $Na_2S_2O_3$ = x cc. N/10 NaOH to neutralize free acid.

$x \times 0.00365 \times 10$ = grams HCl in 100 cc.

$x \times 0.0049 \times 10$ = grams $H_2SO_4$ in 100 cc.

*$Na_2S_2O_3$ in hypo bath.*—Place 10 cc. of 10 per cent potassium iodide solution, 5 cc. of concentrated hydrochloric acid, and 25 cc. of N/10 $K_2Cr_2O_7$, in a 250 cc. glass-stoppered bottle. Place the hypo solution in a burette and titrate the liberated iodine in the bottle, using starch as an indicator. The volume of hypo required contains 0.620 grams of pure $Na_2S_2O_3.5H_2O$. Its strength would be

$$\frac{0.620}{\text{cc. } Na_2S_2O_3 \text{ used.}} \times 100 = \text{grams } Na_2S_2O_3.5H_2O \text{ per 100 cc.}$$

(Note: 1 cc. N/10 $K_2Cr_2O_7$ = 1 cc. N/10 iodine solution.)

1 cc. N/10 iodine solution contains 0.0127 gram of iodine.

$0.0127 \times 25 = 0.3175$ gram of iodine liberated.

$$\underset{(496)}{2Na_2S_2O_3.5H_2O} + \underset{(254)}{I_2} = Na_2S_4O_6 + 2NaI.$$

496 : 254 :: x : 0.3175.

x = 0.620 gram of $Na_2S_2O_3.5H_2O$ in the amount of sample taken.

*Second bath when made up of $NaHSO_3$.*—Determination of $NaHSO_3$: The method is the same as that for $Na_2S_2O_3$ in hypo bath.

$$\frac{0.130 \times 100}{\text{cc. } NaHSO_3 \text{ solution used}} = \text{grams of } NaHSO_3 \text{ per 100 cc. of}$$
solution.

(Note: 1 cc. N/10 $K_2Cr_2O_7$ = 0.0127 gram of I.)

$0.0127 \times 25 = 0.3175$ gram of I liberated.

$$\underset{(104)}{NaHSO_3} + \underset{(254)}{I_2} + H_2O = NaHSO_4 + 2HI.$$

104 : 254 :: x : 0.3175.

x = 0.130 gram of $NaHSO_3$ in cc. of sample taken.

**One-bath chrome liquor:** 1. *Determination of chromium.*—Reagents used are as follows:

N/10 $Na_2S_2O_3$ solution 1 cc. = 0.00173 gram Cr.

10 per cent potassium iodide solution.

Starch solution, 1 gram starch per 100 cc. of water, preserved with formaldehyde.

Concentrated hydrochloric acid.

Sodium peroxide.

Standard N/10 sodium hydroxide.

Phenolphthalein, 1 gram per 100 cc. alcohol.

(*a*) *Determination of Cr in new or spent liquor.*—Pipette 10 cc. into an Erlenmeyer flask, to which add 125 cc. of water and 3 grams of sodium peroxide; add the latter in small portions. Boil the mixture for a half-hour, adding more water if necessary.

Transfer the yellow solution to a 500 cc. beaker; rinsing the Erlenmeyer several times with water. Cool thoroughly, then add 8 cc. of concentrated hydrochloric acid and 10 cc. of potassium iodide solution, and let stand five minutes. The solution must now be perfectly clear and reddish-brown in color. If black particles float on top, more potassium iodide solution is required. If the solution is still yellow or light brown, more acid must be added. Now run in sodium thiosulphate solution from a burette with constant stirring until the

color has changed to a light brown. Then add a few drops of starch indicator after which an intense blue coloration should ensue. Dilute to 400 cc., and add more sodium thiosulphate solution, drop by drop, with constant shaking until the blue color changes to a permanent light green.

*Strength.*—$\frac{\text{No. cc. N/10 } Na_2S_2O_3 \times 0.00173 \times 100}{10}$

or

No. cc. N/10 $Na_2S_2O_3 \times 0.0173$ = grams Cr per 100 cc.

(*b*) *Determination of Cr in stock liquor.*—Pipette 10 cc. of stock chrome liquor into a 500 cc. graduated flask, make up to the mark with water and mix thoroughly by shaking. Pipette off 25 cc. of this diluted solution for analysis. Follow the directions given above.

*Strength.*—No. cc. N/10 $Na_2S_2O_3 \times 0.00173 \times 200$ = grams of Cr per 100 cc. of liquor.

(*c*) *Determination of basicity for diluted chrome liquors.*—Pipette 10 cc. original liquor into a casserole and add about 125 cc. of water. Heat to boiling and add 1 cc. phenolphthalein, then run in standard sodium hydroxide from burette with constant stirring until the supernatant liquid shows a faint pink coloration.

cc. N/10 NaOH $\times$ 0.0048 $\times$ 10

or

cc. N/10 NaOH $\times$ 0.048 = grams of $SO_4$ per 100 cc.

(*d*) *Determination of basicity of stock liquor.*—Pipette 10 cc. of stock chrome liquor into a 500 cc. graduated flask, make up to mark with water and mix thoroughly by shaking. Pipette off 25 cc. of this diluted solution for analysis. Follow directions as given above.

*Strength.*—cc. N/10 NaOH $\times$ 0.0048 $\times$ 200

or

cc. N/10 NaOH $\times$ 0.96 = grams of $SO_4$ per 100 cc.

2. *Use of above results to obtain correct basicity of one-bath chrome liquors.*—The best salts for tanning purposes are the basic salts $Cr_2(OH)_2(SO_4)_2$ or $Cr_2Cl_3(OH)_3$.

The ratio of Cr to $SO_3$ is 104 : 160 or as 52 : 80. From the analysis of the liquor determine the ratio of Cr to $SO_3$ by the proportion

$$\frac{\text{grams Cr in 100 cc.}}{\text{grams } SO_3 \text{ in 100 cc.}} = \frac{52}{x};\ x = \text{grams of } SO_3 \text{ combined with}$$

52 grams of Cr.

If the ratio is above 80 there is too much acid present, and sodium carbonate must be added to bring down the ratio to 52 : 80, while if the ratio is below 80, sulphuric acid must be added to bring the ratio up to standard.

(a) *Assume the analysis shows the ratio to be 52 : 83.2.*—

When ratio is 52 :80; 1 gram of Cr = $\frac{80}{52}$ or 1.54 grams $SO_3$; and when ratio is 52 : 83.2; 1 gram Cr = $\frac{83.2}{52}$ or 1.6 grams $SO_3$.

1.6 — 1.54 = 0.06 gram $SO_3$ to be neutralized for each gram of Cr present.

$$\underset{(98)}{H_2SO_4} + \underset{(286)}{Na_2CO_3.10H_2O} = Na_2SO_4 + H_2O + CO_2 + 10H_2O.$$

$$\frac{Na_2CO_3.10H_2O\ (286)}{SO_3\ \ (80)} = \frac{x}{1};\ x = \frac{286 \times 1}{80};\ x = 3.58 \text{ grams of}$$

$Na_2CO_3.10H_2O$ necessary for every gram of $SO_3$ to be neutralized.

0.06 × 3.58 = 0.2148 gram of $Na_2CO_3.10H_2O$ for each gram of Cr.

$$\frac{\text{grams Cr in 100 cc.} \times \overset{\text{(cc. in gal.)}}{3785} \times 0.2148}{453.6 \times 100\ \text{(grams in 1 lb.)}} = \text{pounds of } Na_2CO_3$$

$10H_2O$ to be added per gallon.

*Summary.*—When the grams of $SO_3$ per one gram of chromium are greater than 1.54, subtract 1.54 from this value and substitute the result in the equation given below.

$$\frac{\text{grams Cr in 100 cc.} \times 37.85 \times ?}{453.6}$$

or

grams Cr in 100 cc. × 0.0834 × ? = pounds of $Na_2CO_3.10H_2O$ to be added per gallon to give the desired basicity.

(*b*) *Assume the ratio is below* 80, *say* 69.16.—Then 1 gram of Cr is combined with

$$\frac{69.16}{52} = 1.33 \text{ grams } SO_3.$$

1.54 — 1.33 = 0.21 gram of $SO_3$ to be added for each gram of Cr.

$$\frac{\text{grams Cr in 100 cc.} \times 3785 \times 0.21 \times \frac{98}{80}}{453.6 \times 100} = \text{pounds of sul-}$$

phuric acid to be added per gallon.

$$\frac{x}{\text{amount } H_2SO_4 \text{ in 1 lb. commercial acid (0.935 lb.)}} = \text{pounds of}$$

commercial acid to be added.

*Summary.*—When the grams of $SO_3$ per one gram of Cr are less than 1.54, subtract this value from 1.54 and substitute the result in the equation given below.

$$\frac{\text{grams Cr in 100 cc.} \times 46.366 \times ?}{424.1}$$

or

grams of Cr in 100 cc. $\times$ 0.1117 $\times$ ? = pounds of commercial $H_2SO_4$ to be added per gallon of solution to give proper basicity.

**Vegetable tanning materials.**—The following are the quantities of the materials to be taken for analysis:

**Unextracted materials**

| | *Grams* | *Cubic centimeters* |
|---|---|---|
| Myrabolans | 20 | 2000 |
| Valonia cups | 20 | 2000 |
| Divi divi | 20 | 2000 |
| Sumac | 20 | 2000 |
| Oak bark | 30 | 1000 |
| Hemlock | 30 | 1000 |
| Chestnut wood | 50 | 1000 |
| Spent tans | 50 | 1000 |

**Extracts**

| | *Grams* | *Cubic centimeters* |
|---|---|---|
| Chestnut 35 to 45° Bé. | 14 | 1000 |
| " 45 to 60° Bé. | 12 | 1000 |
| Myrabolans 0 to 50° Bé. | 14 | 1000 |
| " 50 to 100° Bé. | 13 | 1000 |
| Mangrove 0 to 50° Bé. | 14 | 1000 |
| " 50 to 100° Bé. | 13 | 1000 |
| Quebracho (solid) | 12 | 1000 |
| Myrabolans (solid) | 14-15 | 1000 |
| Mangrove (solid) | 14-15 | 1000 |
| Cutch (solid) | 14-15 | 1000 |
| Quebracho (solid) | 12 | 1000 |

**Tan liquors**

| | *Cubic centimeters* | *Cubic centimeters* |
|---|---|---|
| Barkometer reading 0 to 15° | 200 | 1000 |
| " " 15 to 25° | 100 | 1000 |
| " " 25 to 40° | 50 | 1000 |
| " " 40 to 60° | 25 | 1000 |

Above 60° bk. weigh out 15 to 20 grams, according to strength, and dilute to 1000 cc.

The following corrections should be applied to the barkometer readings: At 70° F. add 1.0 to the reading; at 75° add 1.5; at 80° add 2.0. When the reading is 30 or above, and the temperature is 80° F. or more, add 2.5.

The following determinations are made:

1. Total solids.
2. Soluble solids.
3. Insoluble solids.
4. Tannins.
5. Non-tannins.
6. Specific gravity by Westphal balance at 15.5° C.

## OFFICIAL METHOD OF THE AMERICAN LEATHER CHEMISTS' ASSOCIATION FOR THE ANALYSIS OF VEGETABLE MATERIALS CONTAINING TANNIN

### I. Raw and spent materials

(1) *Caution.*—Proper care must be taken to prevent any change in the water content of raw materials during the sampling and preliminary operations. (See "General" under "Sampling.")

(2) *Preparation of sample.*—The sample must be ground to such a degree of fineness that the entire sample will pass through a sieve of 20 meshes to the linear inch.

(a) The temperature used for drying samples of spent material for grinding must not exceed 60° C.

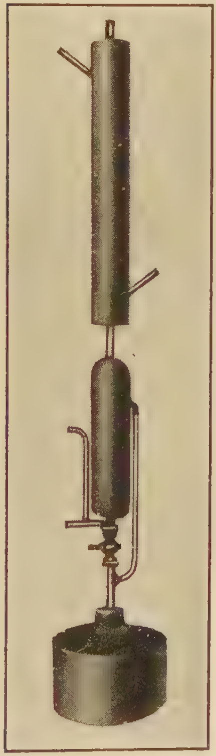

Figure 123.—Tea's extractor.

(b) Samples of raw material too wet to be ground may be dried before grinding as in (a). In this case a preliminary water determination must be made according to (IV) on the sample as received. If the portion of the sample taken for the water determination is in pieces too large to dry properly, it is permissible to reduce these to smaller size as rapidly and with as little loss of water as possible.

(3) *Water determination.*—Ten grams of the ground material shall be dried in the manner and for the period specified for evaporation and drying in extract analysis.

(4) *Amount of sample to be extracted.*—Such an amount of raw material shall be extracted as will give a solution containing as nearly as practicable 0.4 gram tannin to 100 cc. (not less than 0.375 nor more than 0.425). Of spent materials such an amount shall be taken as will give a solution of as nearly as practicable the above concentration.

(5) *Extraction.*—This shall be conducted in an apparatus (figure 123) consisting of a vessel in which water may be boiled and a container for the material to be extracted. The container shall be provided above with a condensation chamber so arranged that the water formed from the condensed steam shall drip on the material to be extracted, and provided below with an arrangement of outlets such that the percolate may either be removed from the apparatus or be delivered to the

boiling vessel. The boiling vessel must be so connected that it will deliver steam to the condensation chamber and that it may receive the percolate from the container. The condensation water from the condenser must be at approximately the boiling temperature when it comes in contact with the material to be extracted.

The material of which the boiling flask is composed must be inert to the extractive solution. Suitable provision must be made for preventing any of the solid particles of the material from passing into the percolate.

(A) Woods, barks and spent materials:

Five hundred cc. of the percolate shall be collected outside in approximately 2 hours and the extraction continued with 500 cc. for 14 hours longer by the process of continuous extraction with reflux condenser. The applied heat shall be such as to give condensation of approximately 500 cc. in $1\frac{1}{2}$ hours.

(B) Materials other than woods, barks and spent:

Digest the material in the extractor for 1 hour with water at room temperature, and then extract by collecting 2 liters of percolate outside in approximately 7 hours.

(6) *Analysis.*—The percolate shall be heated to 80° C., cooled, made to the mark, and analyzed according to the official method of extracts.

## II. Analysis of extract

(7) *Amount and dilution for analysis.*—

(A) Fluid extracts: These shall be allowed to come to room temperature, mixed thoroughly, and such quantity weighed for analysis as will give a solution containing as nearly as possible 0.4 gram tannin to 100 cc. (not less than 0.375 nor more than 0.425). Precautions must be taken to prevent loss of moisture during weighing. Dissolve the extract by washing it into a liter flask with 900 cc. of distilled water at 85° C.

Cooling:

(a) The solutions prepared as above shall be cooled rapidly to 20° C. with water at a temperature of not less than 19° C., be made to the mark with water at 20° C. and the analysis proceeded with at once, or

(b) The solution shall be allowed to stand over night, the temperature of the solution not being permitted to go below 20° C., be brought to 20° C. with water at not less than 19° C., be made to the mark with water at 20° C., and the analysis proceeded with.

(B) Solid and powdered extracts: Such an amount of solid or powdered extract as will give a solution of the strength called for under liquid extracts shall be weighed in a beaker with proper precautions to prevent change of moisture. One hundred cubic centimeters of distilled water at 85° C. shall be added to the extract and the mixture placed on the water-bath, heated, and stirred until a homogeneous solution is obtained. When dissolved, the solution shall immediately be washed into a liter flask with 800 cc. of distilled water at 85° C., be cooled, etc., as under (A) above.

(Note: It is permissible to make up 2-liter instead of 1-liter solutions, dissolving by washing into flask with 1,800 cc. water at 85° C. in case of fluid extracts and 1,700 cc. water at 85° C. in case of solid or powdered extracts.)

(8) *Total solids.*—Thoroughly mix the solutions; pipette 100 cc. into tared dish, evaporate and dry as directed under "Evaporation and Drying." (See IV.)

(9) *Water.*—The water content is shown by the difference between 100 per cent and the total solids.

(10) *Soluble solids.*—S. & S. No. 590, or Munktell's No. 1F, 15 cm. single-pleated filter-paper shall be used for the filtration.

The kaolin used shall answer the following test: 2 grams of kaolin digested with 200 cc. of distilled water at 20° C. for 1 hour shall give not more than 1 mg. of soluble solids per 100 cc., and shall be neutral to phenolphthalein. To 1

gram of kaolin in a beaker add sufficient solution to fill the paper, stir, and pour on paper. Return filtrate to paper when approximately 25 cc. has collected, repeating operation for 1 hour, being careful to transfer all kaolin to the paper. At the end of the hour remove solution from filter-paper, disturbing the kaolin as little as possible. Bring as much as needed of the original solution to exactly 20° C., as described under (7), re-fill the paper with this solution and begin to collect the filtrate for evaporating and drying as soon as it comes clear. The paper must be kept full, and the temperature of the solution on the filter must not fall below 20° C. nor rise above 25° C. during this part of the filtration. The temperature of the solution used for re-filling the paper must be kept uniformly at 20° C., and the funnels and receiving vessels must be kept covered.

Pipette 100 cc. of clear filtrate into tared dish; evaporate and dry as under (8).

(11) *Insolubles.*—The insoluble content is shown by the difference between the total solids and the soluble solids, and represents the matter insoluble in a solution of the concentration used under the temperature conditions prescribed.

(12) *Non-tannins.*—The hide powder used for the non-tannin determination shall be of wooly texture, well de-limed, and shall require between 12 and 13 cc. of N/10 NaOH to neutralize 10 grams of the absolutely dry powder.

(a) Digest the hide powder with 10 times its weight of distilled water till thoroughly soaked. Add 3 per cent of chrome-alum $(Cr_2SO_4)_3K_2SO_4.24H_2O$, in 3 per cent solution calculated on the weight of the air-dry powder. Agitate frequently for several hours, and let stand over night. Squeeze and wash by digesting in the cold with 4 successive portions of distilled water, each portion equal in amount to 15 times the weight of the air-dry powder taken. Each digestion shall last for 15 minutes, and the hide powder shall be squeezed to approximately 75 per cent water after each digestion except the last, a press being used if necessary. The wet hide powder used for the analysis shall contain as nearly as pos-

sible 73 per cent of water, not less than 71 per cent nor more than 74 per cent. Determine the moisture in the wet hide powder by drying approximately 20 grams (see IV). To such quantity of the wet hide as represents as closely as practicable $12\frac{1}{2}$ grams (not less than 12.2 nor more than 12.8) of absolutely dry hide, add 200 cc. of the original analysis solution and shake immediately for 10 minutes in some form of mechanical agitator. Squeeze immediately through linen, add 2 grams of kaolin (answering test described under 9) to the de-tannized solution and filter through single-folded filter (No. 1F Swedish recommended) of size sufficient to hold the entire filtrate, returning until clear. Pipette 100 cc. of filtrate into tared dish, evaporate and dry as in (8).

The weight of the non-tannin residue must be corrected for the dilution caused by the water contained in the wet hide powder.

Funnels and receiving vessels must be kept covered during filtration. Flasks graduated to deliver 200 cc. are reccommended for measuring the analysis solution to be detannized.

(b) Digest the hide powder in the cold with the amount of water and add the amount of chrome-alum in solution directed under (a).

Agitate by some form of mechanical apparatus for 1 hour, and proceed immediately with washing and subsequent operations as directed under (a).

(Note: In order to limit the amount of dry hide powder used, determine the moisture in the air-dry powder and calculate the quantity equal to $12\frac{1}{2}$ grams of actual dry hide powder. Take any multiple of this quantity according to the number of analyses to be made, and after chroming and washing as directed, squeeze to a weight representing as nearly as possible 73 per cent of water. Weigh the whole amount, and divide by the multiple of the $12\frac{1}{2}$ grams of actual dry powder taken to obtain the weight of wet hide powder for 200 cc. of solution.)

(13) *Tannin.*—The tannin content is shown by the difference between the soluble solids and the corrected non-tannins, and represents the matters absorbable by hide under the conditions of the prescribed methods.

## III. Analysis of liquor

(14) *Dilution.*—Liquors shall be diluted for analysis with water at room temperature so as to give as nearly as possible 0.7 gram of solids per 100 cc. of solution. Should a liquor be of such character as not to give a proper solution with water of room temperature it is permissible to dilute with water at 80° C. and cool rapidly as described under (7, A, a).

(15) *Total solids.*—To be determined as in Extract Analysis.

(16) *Soluble solids.*—To be determined as in Extract Analysis.

(17) *Insolubles.*—To be determined as in Extract Analysis.

(18) *Non-tannins.*—To be determined by shaking 200 cc. of solution with an amount of wet chromed hide powder, containing as nearly as possible 73 per cent water, corresponding to an amount of dry hide powder shown in the following table:

| *Tannin range per* 100 *cc.* *Gram* | *Dry powder per* 200 *cc.* *Grams* |
|---|---|
| 0.35—0.45 | 9.0—11.0 |
| 0.25—0.35 | 6.5— 9.0 |
| 0.15—0.25 | 4.0— 6.5 |
| 0.00—0.15 | 0.0— 4.0 |

Solutions to be shaken for non-tannins as in Extract Analysis and 100 cc. evaporated as in Extract Analysis.

## IV. Temperature, evaporation and drying, and dishes

(19) *Temperature.*—The temperature of the several portions of each solution pipetted for evaporating and drying, that is, of the total solids, soluble solids and non-tannins, must be identical at the time of pipetting.

(20) *Evaporation.*—All evaporations and dryings shall be conducted in the form of apparatus known as the "combined evaporator and dryer" (figure 124) at a temperature not less than 98° C. The time for evaporation and drying shall be 16 hours.

(21) *Dishes.*—The dishes used for evaporation and drying

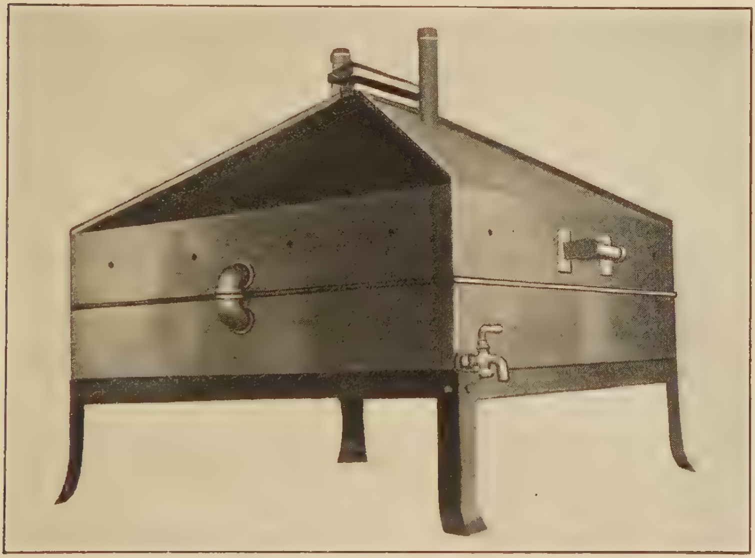

**Figure 124.—Combined evaporator and dryer.**

of all residues shall be flat-bottomed glass dishes not less than $2\frac{3}{4}$ inches nor more than 3 inches in diameter.

## V. Determination of total acidity of liquors

(22) *Reagents.*—(a) One per cent solution of gelatine neutral to hematin. The addition of 25 cc. of 95 per cent alcohol per liter is recommended to prevent frothing. If the gelatine solution is alkaline, neutralize with tenth normal acetic acid, and if acid, neutralize with tenth normal sodium hydroxide.

(b) Hematin. A solution made by digesting hematin in cold neutral 95 per cent alcohol in the proportion of $\frac{1}{2}$ gram of the former to 100 cc. of the latter.

(c) Acid-washed kaolin free from soluble matters.

(d) Tenth normal sodium hydroxide.

*Directions.*—To 25 cc. of the liquor in a cylinder that can be stoppered, add 50 cc. of gelatine solution, dilute with water to 250 cc., add 15 grams of kaolin and shake vigorously. Allow to settle for at least 15 minutes, remove 30 cc. of the supernatant solution, dilute with 50 cc. of water, and titrate with tenth normal soda, using hematin solution as the indicator. Each cubic centimeter of tenth normal soda is equivalent to 0.2 per cent acid as acetic.

## VI. General

(23) When materials containing sulphite cellulose extract are analyzed, the fact that the material contains this extract shall be noted in the report.

(24) The test for the presence of sulphite cellulose in a liquor or extract shall be as follows: 5 cc. of a solution of analytical strength shall be placed in a test-tube, 0.5 cc. of aniline added and the whole well shaken; then 2 cc. of strong hydrochloric acid added and the mixture again shaken. If at least as much precipitate remains as is obtained when a comparison solution prepared as below is similarly treated, the material shall be held to contain sulphite cellulose. (Neradol D gives the same reaction.)

The comparison solution shall consist of sulphite cellulose in the proportion of 1 part total solids to 2,000 cc. of solution, and as much tanning material, similar to that being tested, but known to be free from sulphite cellulose, as will make up the solution to analytical strength.

(25) On public analytical work by members of this Association the fact that the official method has been used shall be stated.

## OFFICIAL METHOD FOR SAMPLING TANNING MATERIALS

*General.*—Extract, whether liquid or solid, and tanning materials in general, all contain moisture. The amount of mois-

ture varies with climatic conditions, but especially in liquid, and in most solid extracts becomes less as the extract is exposed to the air. As the value of any material shown by analysis is directly dependent upon the amount of moisture contained, and as an exposure of a comparatively few moments may alter appreciably the amount of moisture, it is apparent that the sampling in all its details should be done as quickly as consistent with thoroughness and with great care to expose the material as little as possible to the air. The portions taken as samples should be placed at once in containers as nearly air-tight as possible, and preferably of glass. Wood, cardboard, poorly glazed crockery, etc., are all porous and more or less absorbent and not suitable for retaining samples.

Liquid extract cannot be accurately sampled when it contains any frozen material. A sample of extract taken after live steam has been run into the extract has not the same concentration as the original extract. A sample of spent bark which has been standing where dust from freshly ground bark has sifted into it does not represent the degree of extraction of the spent bark. Samples of liquor which have been kept with no preservative in them for some time do not represent the condition of the liquor when sampled.

All extracts and crude tanning materials shall be sampled as nearly as possible at time of weighing, and for every 50,000 lb. or less sampled, a sample shall be drawn.

(1) *Solid, powdered and pasty extracts.*—The number of packages to be sampled out of a given lot shall be ascertained by taking a percentage of the total number of packages in the lot obtained in the following manner: Divide the total number of packages by 100, multiply by 0.02, and subtract from 4.

Thus

$$4{,}700 \div 100 = 47$$
$$47 \times 0.02 = 0.94$$
$$4 - 0.94 = 3.06 \text{ per cent}$$
$$4{,}700 \times 0.0306 = 144 \text{ packages}$$

Provided that for lots of 200 packages and under, 5 per cent of the number of packages shall be sampled; and for lots of 10,000 packages and over, 2 per cent of the number of packages shall be sampled.

Whenever possible every Nth package shall be set aside for sampling while the extract is being moved. When this is not possible, the packages shall be selected from as uniformly distributed parts of the bulk as possible.

Samples of as nearly equal size as practicable shall be taken from each package, and these samples shall represent as nearly as may be, proportionally the outer and inner portions of the extract. These sub-samples shall be placed in a clean, dry, closed container. When sampling is completed, the whole composite sample shall be broken up until it will pass through a sieve of 1-inch mesh; it shall be reduced to the required bulk by successive mixings and quarterings. From this bulk, duplicate samples of at least 6 ounces shall be drawn from opposite quarters by means of a small flat scoop (and not by selecting a handful here and there). The sample shall be enclosed in the smallest clean, dry, glass receptacle, sealed and properly labeled.

(Note: Whenever possible, the sample should be wrapped in paraffin paper and placed in the smallest straight-side glass receptacle; especially is this desirable during the warmer months of the year.)

Sampling at place of manufacture shall be conducted by running a portion from the middle of each strike into a mold holding at least 2 lb. These sub-samples shall be preserved with proper precautions against evaporation, and be sampled for analysis as above.

(2) *Liquid extracts in barrels.*—The number of barrels of extracts to be sampled out of any given lot shall be not less than 10 per cent of the whole number of barrels for every 50,000 lb. or fraction thereof. The barrels to be sampled shall be rolled and shaken from end to end until the contents are homogeneous. Whenever this is not possible the heads

of the barrels shall be removed and the contents stirred until homogeneous, a sample of equal size to be taken from each barrel. These sub-samples shall be put together in a suitable closed container and thoroughly mixed. From this bulk, duplicate samples of at least 4 oz. shall be drawn and preserved in clean, dry, glass containers; sealed and labeled with such distinguishing marks as may be necessary.

(3) *Liquid extract in bulk.*—The extract shall be agitated with air, plunged or mixed by some other efficient means until homogeneous. Equal samples shall then be taken from different parts of the bulk, placed in a proper container, thoroughly mixed, and sampled as described in (2).

(4) *Liquid extract in tank-cars.*—The following methods are permissible:

(a) The extract shall be unloaded into clean, dry containers and sampled according to (3).

(b) The extract shall be mixed until homogeneous, by plunging through the dome or other effective means, then numerous equal samples shall be taken from as widely scattered parts of the bulk as possible. These samples shall then be placed in a suitable container, be mixed and sampled as in (2).

(Note: As it is almost impossible to secure a homogeneous mixture of the extract in a tank-car, this method should be used only when no other is possible.)

(c) The extract shall be sampled as follows while the car is being unloaded: A quart sample shall be taken from the discharge three minutes after the extract has begun to run: another quart sample shall be taken three minutes before the extract has all run out, and three other quart samples shall be taken at equal intervals between these two. These five samples shall be transferred to a suitable container as soon as taken, be thoroughly mixed and sampled as in (2).

(5) *Crude tanning materials.*—(A) Shipments in bags, mats or other similar packages.

A number of packages shall be sampled representing 2 per

cent of the weight for every shipment of 50,000 lb. or fraction thereof, by taking representative portions from each package. These sub-samples shall be mixed together and the bulk reduced by mixing and quartering to the desired size. Duplicate samples of not less than 5 lb. each shall be preserved in air-tight containers properly labeled.

(B) Shipments in bulk, bark, wood, etc., in sticks.

Sticks shall be taken from at least ten uniformly distributed parts of the bulk, sawed completely through, and the sawdust thoroughly mixed and sampled as in A.

(C) Materials prepared for leaching.

Samples of equal size shall be taken at uniform intervals as the material enters the leach and be kept in a suitable container till sampling is completed. This bulk shall then be thoroughly mixed, be reduced by mixing and quartering, and duplicate samples for analysis of at least 2 lb. in size be preserved in air-tight containers, as in A.

(6) *Spent materials from leaches.*—Samples of spent material shall be taken from the top, middle, and bottom, and in each case from the center and outer portions of the leach. These sub-samples shall be thoroughly mixed, reduced in bulk by mixing and quartering, and duplicate samples of at least 1 quart in size preserved for analysis.

(7) *Tanning liquors.*—The liquor shall be mixed by plunging or other effective means till homogeneous and then samples of at least 1 pint be taken for analysis. The addition of 0.03 per cent of thymol or other suitable anti-ferment to the sample is essential to keep the liquor from altering its original condition.

When routine samples are taken from day to day and a composite sample analyzed, samples of equal size shall be taken from each vat after thorough mixing, preserved in covered containers in as cool a place as possible, and kept from fermentation by the addition of suitable anti-ferment, as above. This bulk shall be mixed till homogeneous, and samples of not less than 1 pint each preserved for analysis.

When a sample is taken by a member of this Association in accordance with the above method, it is requested that he state on the label of the sample submitted and on the analysis blank that "this sample has been taken in accordance with the official method of sampling of The American Leather Chemists' Association."

## OFFICIAL METHOD FOR ANALYSIS OF VEGETABLE-TANNED LEATHER

(1) *Preparation of sample.*—The sample of leather for analysis shall be reduced to as fine a state of division as practicable, either by cutting or grinding.

(2) *Moisture.*—Dry 10 grams of leather for 16 hours at a temperature between 95 and 100° C.

(3) *Fats.*—Extract 5 to 10 grams of air-dry leather in a Soxhlet apparatus until free from grease, using petroleum ether boiling below 80° C. Evaporate off the ether and dry to approximately constant weight.

Or, if preferred, extract 30 grams of leather as described above. In the latter case, the extracted leather, when freed of solvent, may be used for the determination of water-soluble material.

(4) *Ash.*—Incinerate 10 to 15 grams of leather in a tared dish at a dull red heat until carbon is consumed. If it is difficult to burn off all the carbon, treat the ash with hot water, filter through an ashless filter, ignite filter and residue. Add the filtrate, evaporate to dryness, and ignite.

(5) *Water-soluble material.*—Digest 30 grams of leather in a percolator over night, then extract with water at 50° C. for 3 hours, the total volume of the solution to be 2 liters. Determine total solids and non-tannins according to the official method for Extract Analysis.

(6) *Glucose.*—

Solutions

*Copper sulphate.*—Dissolve 34.639 grams of $CuSO_4.5H_2O$ in distilled water and dilute to 500 cc. Filter through asbestos.

*Alkaline tartrate solution.*—Dissolve 173 grams of Rochelle salt and 50 grams NaOH in water and dilute to 500 cc. Allow to stand 2 days and filter through asbestos.

*Normal lead acetate solution.*—Prepare a saturated solution of normal lead acetate.

## Determination

Place 200 cc. of leather extract of analytical strength in a ½-liter flask, add 25 cc. of a saturated solution of normal lead acetate, shake frequently (5 to 10 minutes), and filter. (The funnels and beakers must be kept covered to prevent evaporation.) Add to the filtrate an excess of solid potassium oxalate. Mix frequently for 15 minutes and filter, returning the filtrate until clear. Pipette 150 cc. of this filtrate into a 600 cc. Erlenmeyer flask, add 5 cc. of concentrated HCl and boil under a reflux condenser for 2 hours. Cool, neutralize (place a small piece of litmus paper in the flask) with anhydrous sodium carbonate, transfer to a 200 cc. graduated flask, and make to volume. Filter through a double filter (the filtrate must be clear). Determine the dextrose in the solution immediately.

Place 25 cc. of the copper solution and 25 cc. of the alkaline tartrate solution in a 400 cc. beaker. Add 50 cc. of the clarified and neutralized solution above mentioned, and heat to boiling in exactly 4 minutes and boil for 2 minutes.[1] Filter immediately without diluting, through asbestos,[2] wash thoroughly with hot water, then with alcohol, and finally with ether; dry for ½ hour in water-oven, and weigh as cuprous oxide, determine the amount of dextrose by the use of Munson and Walker's table, and report in percentage on leather.

[1] The rate of heating of the Bunsen burner used should be regulated before sugar determinations are started. This is best done by adjusting the burner so as to bring 25 cc. copper solution + 25 cc. alkaline tartrate solution + 50 cc. $H_2O$ in a 400 cc. beaker to 100° C. in exactly four minutes.

[2] The finely divided, long-fibered asbestos to be used in the glucose determination should be digested with $HNO_3$, washed, then digested with NaOH and washed. When Gooch filters are prepared, they should be washed with boiling Fehling's solution, then with $HNO_3$. The mats thus prepared can be used for a long time

**Munson and Walker's Table**

(Bulletin 107 [Revised], Bureau of Chemistry, page 243.)
(Expressed in milligrams.)

| Cuprous oxide ($Cu_2O$) | Copper (Cu) | Dextrose (*d*-glucose) | Cuprous oxide ($Cu_2O$) | Copper (Cu) | Dextrose (*d*-glucose) |
|---|---|---|---|---|---|
| 10 | 8.9 | 4.0 | 45 | 40.0 | 19.1 |
| 11 | 9.8 | 4.5 | 46 | 40.9 | 19.6 |
| 12 | 10.7 | 4.9 | 47 | 41.7 | 20.0 |
| 13 | 11.5 | 5.3 | 48 | 42.6 | 20.4 |
| 14 | 12.4 | 5.7 | 49 | 43.5 | 20.9 |
| 15 | 13.3 | 6.2 | 50 | 44.4 | 21.3 |
| 16 | 14.2 | 6.6 | 51 | 45.3 | 21.7 |
| 17 | 15.1 | 7.0 | 52 | 46.2 | 22.2 |
| 18 | 16.0 | 7.5 | 53 | 47.1 | 22.6 |
| 19 | 16.9 | 7.9 | 54 | 48.0 | 23.0 |
| 20 | 17.8 | 8.3 | 55 | 48.9 | 23.5 |
| 21 | 18.7 | 8.7 | 56 | 49.7 | 23.9 |
| 22 | 19.5 | 9.2 | 57 | 50.6 | 24.3 |
| 23 | 20.4 | 9.6 | 58 | 51.5 | 24.8 |
| 24 | 21.3 | 10.0 | 59 | 52.4 | 25.2 |
| 25 | 22.2 | 10.5 | 60 | 53.3 | 25.6 |
| 26 | 23.1 | 10.9 | 61 | 54.2 | 26.1 |
| 27 | 24.0 | 11.3 | 62 | 55.1 | 26.5 |
| 28 | 24.9 | 11.8 | 63 | 56.0 | 27.0 |
| 29 | 25.8 | 12.2 | 64 | 56.8 | 27.4 |
| 30 | 26.6 | 12.6 | 65 | 57.7 | 27.8 |
| 31 | 27.5 | 13.1 | 66 | 58.6 | 28.3 |
| 32 | 28.4 | 13.5 | 67 | 59.5 | 28.7 |
| 33 | 29.3 | 13.9 | 68 | 60.4 | 29.2 |
| 34 | 30.2 | 14.3 | 69 | 61.3 | 29.6 |
| 35 | 31.1 | 14.8 | 70 | 62.2 | 30.0 |
| 36 | 32.0 | 15.2 | 71 | 63.1 | 30.5 |
| 37 | 32.9 | 15.6 | 72 | 64.0 | 30.9 |
| 38 | 33.8 | 16.1 | 73 | 64.8 | 31.4 |
| 39 | 34.6 | 16.5 | 74 | 65.7 | 31.8 |
| 40 | 35.5 | 16.9 | 75 | 66.6 | 32.2 |
| 41 | 36.4 | 17.4 | 76 | 67.5 | 32.7 |
| 42 | 37.3 | 17.8 | 77 | 68.4 | 33.1 |
| 43 | 38.2 | 18.2 | 78 | 69.3 | 33.6 |
| 44 | 39.1 | 18.7 | 79 | 70.2 | 34.0 |

| Cuprous oxide ($Cu_2O$) | Copper (Cu) | Dextrose (*d*-glucose) | Cuprous oxide ($Cu_2O$) | Copper (Cu) | Dextrose (*d*-glucose) |
|---|---|---|---|---|---|
| 80 | 71.1 | 34.4 | 115 | 102.2 | 50.0 |
| 81 | 71.9 | 34.9 | 116 | 103.0 | 50.5 |
| 82 | 72.8 | 35.3 | 117 | 103.9 | 50.9 |
| 83 | 73.7 | 35.8 | 118 | 104.8 | 51.4 |
| 84 | 74.6 | 36.2 | 119 | 105.7 | 51.8 |
| 85 | 75.5 | 36.7 | 120 | 106.6 | 52.3 |
| 86 | 76.4 | 37.1 | 121 | 107.5 | 52.7 |
| 87 | 77.3 | 37.5 | 122 | 108.4 | 53.2 |
| 88 | 78.2 | 38.0 | 123 | 109.3 | 53.6 |
| 89 | 79.1 | 38.4 | 124 | 110.1 | 54.1 |
| 90 | 79.9 | 38.9 | 125 | 111.0 | 54.5 |
| 91 | 80.8 | 39.3 | 126 | 111.9 | 55.0 |
| 92 | 81.7 | 39.8 | 127 | 112.8 | 55.4 |
| 93 | 82.6 | 40.2 | 128 | 113.7 | 55.9 |
| 94 | 83.5 | 40.6 | 129 | 114.6 | 56.3 |
| 95 | 84.4 | 41.1 | 130 | 115.5 | 56.8 |
| 96 | 85.3 | 41.5 | 131 | 116.4 | 57.2 |
| 97 | 86.2 | 42.0 | 132 | 117.3 | 57.7 |
| 98 | 87.1 | 42.4 | 133 | 118.1 | 58.1 |
| 99 | 87.9 | 42.9 | 134 | 119.0 | 58.6 |
| 100 | 88.8 | 43.3 | 135 | 119.9 | 59.0 |
| 101 | 89.7 | 43.8 | 136 | 120.8 | 59.5 |
| 102 | 90.6 | 44.2 | 137 | 121.7 | 60.0 |
| 103 | 91.5 | 44.7 | 138 | 122.6 | 60.4 |
| 104 | 92.4 | 45.1 | 139 | 123.5 | 60.9 |
| 105 | 93.3 | 45.5 | 140 | 124.4 | 61.3 |
| 106 | 94.2 | 46.0 | 141 | 125.2 | 61.8 |
| 107 | 95.0 | 46.4 | 142 | 126.1 | 62.2 |
| 108 | 95.9 | 46.9 | 143 | 127.0 | 62.7 |
| 109 | 96.8 | 47.3 | 144 | 127.9 | 63.1 |
| 110 | 97.7 | 47.8 | 145 | 128.8 | 63.6 |
| 111 | 98.6 | 48.2 | 146 | 129.7 | 64.0 |
| 112 | 99.5 | 48.7 | 147 | 130.6 | 64.5 |
| 113 | 100.4 | 49.1 | 148 | 131.5 | 65.0 |
| 114 | 101.3 | 49.6 | 149 | 132.4 | 65.4 |

| Cuprous oxide ($Cu_2O$) | Copper (Cu) | Dextrose (*d*-glucose) | Cuprous oxide ($Cu_2O$) | Copper (Cu) | Dextrose (*d*-glucose) |
|---|---|---|---|---|---|
| 150 | 133.2 | 65.9 | 185 | 164.3 | 82.0 |
| 151 | 134.1 | 66.3 | 186 | 165.2 | 82.5 |
| 152 | 135.0 | 66.8 | 187 | 166.1 | 82.9 |
| 153 | 135.9 | 67.2 | 188 | 167.0 | 83.4 |
| 154 | 136.8 | 67.7 | 189 | 167.9 | 83.9 |
| 155 | 137.7 | 68.2 | 190 | 168.8 | 84.3 |
| 156 | 138.6 | 68.6 | 191 | 169.7 | 84.8 |
| 157 | 139.5 | 69.1 | 192 | 170.5 | 85.3 |
| 158 | 140.3 | 69.5 | 193 | 171.4 | 85.7 |
| 159 | 141.2 | 70.0 | 194 | 172.3 | 86.2 |
| 160 | 142.1 | 70.4 | 195 | 173.2 | 86.7 |
| 161 | 143.0 | 70.9 | 196 | 174.1 | 87.1 |
| 162 | 143.9 | 71.4 | 197 | 175.0 | 87.6 |
| 163 | 144.8 | 71.8 | 198 | 175.9 | 88.1 |
| 164 | 145.7 | 72.3 | 199 | 176.8 | 88.5 |
| 165 | 146.6 | 72.8 | 200 | 177.7 | 89.0 |
| 166 | 147.5 | 73.2 | 201 | 178.5 | 89.5 |
| 167 | 148.3 | 73.7 | 202 | 179.4 | 89.9 |
| 168 | 149.2 | 74.1 | 203 | 180.3 | 90.4 |
| 169 | 150.1 | 74.6 | 204 | 181.2 | 90.9 |
| 170 | 151.0 | 75.1 | 205 | 182.1 | 91.4 |
| 171 | 151.9 | 75.5 | 206 | 183.0 | 91.8 |
| 172 | 152.8 | 76.0 | 207 | 183.9 | 92.3 |
| 173 | 153.7 | 76.4 | 208 | 184.8 | 92.8 |
| 174 | 154.6 | 76.9 | 209 | 185.6 | 93.2 |
| 175 | 155.5 | 77.4 | 210 | 186.5 | 93.7 |
| 176 | 156.3 | 77.8 | 211 | 187.4 | 94.2 |
| 177 | 157.2 | 78.3 | 212 | 188.3 | 94.6 |
| 178 | 158.1 | 78.8 | 213 | 189.2 | 95.1 |
| 179 | 159.0 | 79.2 | 214 | 190.1 | 95.6 |
| 180 | 159.9 | 79.7 | 215 | 191.0 | 96.1 |
| 181 | 160.8 | 80.1 | 216 | 191.9 | 96.5 |
| 182 | 161.7 | 80.6 | 217 | 192.8 | 97.0 |
| 183 | 162.6 | 81.1 | 218 | 193.6 | 97.5 |
| 184 | 163.4 | 81.5 | 219 | 194.5 | 98.0 |

| Cuprous oxide ($Cu_2O$) | Copper (Cu) | Dextrose (*d*-glucose) | Cuprous oxide ($Cu_2O$) | Copper (Cu) | Dextrose (*d*-glucose) |
|---|---|---|---|---|---|
| 220 | 195.4 | 98.4 | 255 | 226.5 | 115.2 |
| 221 | 196.3 | 98.9 | 256 | 227.4 | 115.7 |
| 222 | 197.2 | 99.4 | 257 | 228.3 | 116.1 |
| 223 | 198.1 | 99.9 | 258 | 229.2 | 116.6 |
| 224 | 199.0 | 100.3 | 259 | 230.1 | 117.1 |
| 225 | 199.9 | 100.8 | 260 | 231.0 | 117.6 |
| 226 | 200.7 | 101.3 | 261 | 231.8 | 118.1 |
| 227 | 201.6 | 101.8 | 262 | 232.7 | 118.6 |
| 228 | 202.5 | 102.2 | 263 | 233.6 | 119.0 |
| 229 | 203.4 | 102.7 | 264 | 234.5 | 119.5 |
| 230 | 204.3 | 103.2 | 265 | 235.4 | 120.0 |
| 231 | 205.2 | 103.7 | 266 | 236.3 | 120.5 |
| 232 | 206.1 | 104.1 | 267 | 237.2 | 121.0 |
| 233 | 207.0 | 104.6 | 268 | 238.1 | 121.5 |
| 234 | 207.9 | 105.1 | 269 | 238.9 | 122.0 |
| 235 | 208.7 | 105.6 | 270 | 239.8 | 122.5 |
| 236 | 209.6 | 106.0 | 271 | 240.7 | 122.9 |
| 237 | 210.5 | 106.5 | 272 | 241.6 | 123.4 |
| 238 | 211.4 | 107.0 | 273 | 242.5 | 123.9 |
| 239 | 212.3 | 107.5 | 274 | 243.4 | 124.4 |
| 240 | 213.2 | 108.0 | 275 | 244.3 | 124.9 |
| 241 | 214.1 | 108.4 | 276 | 245.2 | 125.4 |
| 242 | 215.0 | 108.9 | 277 | 246.1 | 125.9 |
| 243 | 215.8 | 109.4 | 278 | 246.9 | 126.4 |
| 244 | 216.7 | 109.9 | 279 | 247.8 | 126.9 |
| 245 | 217.6 | 110.4 | 280 | 248.7 | 127.3 |
| 246 | 218.5 | 110.8 | 281 | 249.6 | 127.8 |
| 247 | 219.4 | 111.3 | 282 | 250.5 | 128.3 |
| 248 | 220.2 | 111.8 | 283 | 251.4 | 128.8 |
| 249 | 221.2 | 112.3 | 284 | 252.3 | 129.3 |
| 250 | 222.1 | 112.8 | 285 | 253.2 | 129.8 |
| 251 | 223.0 | 113.2 | 286 | 254.0 | 130.3 |
| 252 | 223.8 | 113.7 | 287 | 254.9 | 130.8 |
| 253 | 224.7 | 114.2 | 288 | 255.8 | 131.3 |
| 254 | 225.6 | 114.7 | 289 | 256.7 | 131.8 |

| Cuprous oxide ($Cu_2O$) | Copper (Cu) | Dextrose (*d*-glucose) | Cuprous oxide ($Cu_2O$) | Copper (Cu) | Dextrose (*d*-glucose) |
|---|---|---|---|---|---|
| 290 | 257.6 | 132.3 | 325 | 288.7 | 149.7 |
| 291 | 258.5 | 132.7 | 326 | 289.6 | 150.2 |
| 292 | 259.4 | 133.2 | 327 | 290.5 | 150.7 |
| 293 | 260.3 | 133.7 | 328 | 291.4 | 151.2 |
| 294 | 261.2 | 134.2 | 329 | 292.2 | 151.7 |
| 295 | 262.0 | 134.7 | 330 | 293.1 | 152.2 |
| 296 | 262.9 | 135.2 | 331 | 294.0 | 152.7 |
| 297 | 263.8 | 135.7 | 332 | 294.9 | 153.2 |
| 298 | 264.7 | 136.2 | 333 | 295.8 | 153.7 |
| 299 | 265.6 | 136.7 | 334 | 296.7 | 154.2 |
| 300 | 266.5 | 137.2 | 335 | 297.6 | 154.7 |
| 301 | 267.4 | 137.7 | 336 | 298.5 | 155.2 |
| 302 | 268.3 | 138.2 | 337 | 299.3 | 155.8 |
| 303 | 269.1 | 138.7 | 338 | 300.2 | 156.3 |
| 304 | 270.0 | 139.2 | 339 | 301.1 | 156.8 |
| 305 | 270.9 | 139.7 | 340 | 302.0 | 157.3 |
| 306 | 271.8 | 140.2 | 341 | 302.9 | 157.8 |
| 307 | 272.7 | 140.7 | 342 | 303.8 | 158.3 |
| 308 | 273.6 | 141.2 | 343 | 304.7 | 158.8 |
| 309 | 274.5 | 141.7 | 344 | 305.6 | 159.3 |
| 310 | 275.4 | 142.2 | 345 | 306.5 | 159.8 |
| 311 | 276.3 | 142.7 | 346 | 307.3 | 160.3 |
| 312 | 277.1 | 143.2 | 347 | 308.2 | 160.8 |
| 313 | 278.0 | 143.7 | 348 | 309.1 | 161.4 |
| 314 | 278.9 | 144.2 | 349 | 310.0 | 161.9 |
| 315 | 279.8 | 144.7 | 350 | 310.9 | 162.4 |
| 316 | 280.7 | 145.2 | 351 | 311.8 | 162.9 |
| 317 | 281.6 | 145.7 | 352 | 312.7 | 163.4 |
| 318 | 282.5 | 146.2 | 353 | 313.6 | 163.9 |
| 319 | 283.4 | 146.7 | 354 | 314.4 | 164.4 |
| 320 | 284.2 | 147.2 | 355 | 315.3 | 164.9 |
| 321 | 285.1 | 147.7 | 356 | 316.2 | 165.4 |
| 322 | 286.0 | 148.2 | 357 | 317.1 | 166.0 |
| 323 | 286.9 | 148.7 | 358 | 318.0 | 166.5 |
| 324 | 287.8 | 149.2 | 359 | 318.9 | 167.0 |

| Cuprous oxide ($Cu_2O$) | Copper (Cu) | Dextrose (*d*-glucose) | Cuprous oxide ($Cu_2O$) | Copper (Cu) | Dextrose (*d*-glucose) |
|---|---|---|---|---|---|
| 360 | 319.8 | 167.5 | 395 | 350.9 | 185.7 |
| 361 | 320.7 | 168.0 | 396 | 351.8 | 186.2 |
| 362 | 321.6 | 168.5 | 397 | 352.6 | 186.8 |
| 363 | 322.4 | 169.0 | 398 | 353.5 | 187.3 |
| 364 | 323.3 | 169.6 | 399 | 354.4 | 187.8 |
| 365 | 324.2 | 170.1 | 400 | 355.3 | 188.4 |
| 366 | 325.1 | 170.6 | 401 | 356.2 | 188.9 |
| 367 | 326.0 | 171.1 | 402 | 357.1 | 189.4 |
| 368 | 326.9 | 171.6 | 403 | 358.0 | 189.9 |
| 369 | 327.8 | 172.1 | 404 | 358.9 | 190.5 |
| 370 | 328.7 | 172.7 | 405 | 359.7 | 191.0 |
| 371 | 329.5 | 173.2 | 406 | 360.6 | 191.5 |
| 372 | 330.4 | 173.7 | 407 | 361.5 | 192.1 |
| 373 | 331.3 | 174.2 | 408 | 362.4 | 192.6 |
| 374 | 332.2 | 174.7 | 409 | 363.3 | 193.1 |
| 375 | 333.1 | 175.3 | 410 | 364.2 | 193.7 |
| 376 | 334.0 | 175.8 | 411 | 365.1 | 194.2 |
| 377 | 334.9 | 176.3 | 412 | 366.0 | 194.7 |
| 378 | 335.8 | 176.8 | 413 | 366.9 | 195.2 |
| 379 | 336.7 | 177.3 | 414 | 367.7 | 195.8 |
| 380 | 337.5 | 177.9 | 415 | 368.6 | 196.3 |
| 381 | 338.4 | 178.4 | 416 | 369.5 | 196.8 |
| 382 | 339.3 | 178.9 | 417 | 370.4 | 197.4 |
| 383 | 340.2 | 179.4 | 418 | 371.3 | 197.9 |
| 384 | 341.1 | 180.0 | 419 | 372.2 | 198.4 |
| 385 | 342.0 | 180.5 | 420 | 373.1 | 199.0 |
| 386 | 342.9 | 181.0 | 421 | 374.0 | 199.5 |
| 387 | 343.8 | 181.5 | 422 | 374.8 | 200.1 |
| 388 | 344.6 | 182.0 | 423 | 375.7 | 200.6 |
| 389 | 345.5 | 182.6 | 424 | 376.6 | 201.1 |
| 390 | 346.4 | 183.1 | 425 | 377.5 | 201.7 |
| 391 | 347.3 | 183.6 | 426 | 378.4 | 202.2 |
| 392 | 348.2 | 184.1 | 427 | 379.3 | 202.8 |
| 393 | 349.1 | 184.7 | 428 | 380.2 | 203.3 |
| 394 | 350.0 | 185.2 | 429 | 381.1 | 203.8 |

| Cuprous oxide ($Cu_2O$) | Copper (Cu) | Dextrose (*d*-glucose) | Cuprous oxide ($Cu_2O$) | Copper (Cu) | Dextrose (*d*-glucose) |
|---|---|---|---|---|---|
| 430 | 382.0 | 204.4 | 460 | 408.6 | 220.7 |
| 431 | 382.8 | 204.9 | 461 | 409.5 | 221.3 |
| 432 | 383.7 | 205.5 | 462 | 410.4 | 221.8 |
| 433 | 384.6 | 206.0 | 463 | 411.3 | 222.4 |
| 434 | 385.5 | 206.5 | 464 | 412.2 | 222.9 |
| 435 | 386.4 | 207.1 | 465 | 413.0 | 223.5 |
| 436 | 387.3 | 207.6 | 466 | 413.9 | 224.0 |
| 437 | 388.2 | 208.2 | 467 | 414.8 | 224.6 |
| 438 | 389.1 | 208.7 | 468 | 415.7 | 225.1 |
| 439 | 390.0 | 209.2 | 469 | 416.6 | 225.7 |
| 440 | 390.8 | 209.8 | 470 | 417.5 | 226.2 |
| 441 | 391.7 | 210.3 | 471 | 418.4 | 226.8 |
| 442 | 392.6 | 210.9 | 472 | 419.3 | 227.4 |
| 443 | 393.5 | 211.4 | 473 | 420.2 | 227.9 |
| 444 | 394.4 | 212.0 | 474 | 421.0 | 228.5 |
| 445 | 395.3 | 212.5 | 475 | 421.9 | 229.0 |
| 446 | 396.2 | 213.1 | 476 | 422.8 | 229.6 |
| 447 | 397.1 | 213.6 | 477 | 423.7 | 230.1 |
| 448 | 397.9 | 214.1 | 478 | 424.6 | 230.7 |
| 449 | 398.8 | 214.7 | 479 | 425.5 | 231.3 |
| 450 | 399.7 | 215.2 | 480 | 426.4 | 231.8 |
| 451 | 400.6 | 215.8 | 481 | 427.3 | 232.4 |
| 452 | 401.5 | 216.3 | 482 | 428.1 | 232.9 |
| 453 | 402.4 | 216.9 | 483 | 429.0 | 233.5 |
| 454 | 403.3 | 217.4 | 484 | 429.9 | 234.1 |
| 455 | 404.2 | 218.0 | 485 | 430.8 | 234.6 |
| 456 | 405.1 | 218.5 | 486 | 431.7 | 235.2 |
| 457 | 405.9 | 219.1 | 487 | 432.6 | 235.7 |
| 458 | 406.8 | 219.6 | 488 | 433.5 | 236.3 |
| 459 | 407.7 | 220.2 | 489 | 434.4 | 236.9 |
| | | | 490 | 435.3 | 237.4 |

(7) *Nitrogen.*—Gunning modification of the Kjeldahl method, A. O. A. C. Bulletin, No. 107 (1907).

## Reagents

*Standard acid solutions.*—Hydrochloric or sulphuric acid, the absolute strength of which has been accurately determined: For ordinary work half-normal acid is recommended. For work in determining very small amounts of nitrogen, tenth-normal is recommended. In titrating mineral acid against hydroxide solution use cochineal as indicator.

*Standard alkali solution.*—The strength of this solution relative to the acid must be accurately determined; tenth-normal solution is recommended.

*Sulphuric acid.*—The sulphuric acid used should have a specific gravity of 1.84 and be free from nitrates, also from ammonium sulphate.

*Sodium hydroxide solution.*—A saturated solution of sodium hydroxide free from nitrates.

*Potassium sulphate.*—This reagent should be pulverized before using.

*Indicator.*—A solution of cochineal is prepared by digesting and frequently agitating 3 grams of pulverized cochineal in a mixture of 50 cc. of strong alcohol and 200 cc. of distilled water for a day or two at ordinary temperature; the filtered solution is employed as indicator.

## Determination

Place 0.7 gram of leather in a digestion flask. Add 10 grams of powdered potassium sulphate and from 15 to 25 cc. (ordinarily about 20 cc.) of concentrated sulphuric acid. Place the flask in an inclined position and heat below the boiling point of the acid from 5 to 15 minutes, or until frothing has ceased (a small piece of paraffin may be added to prevent extreme foaming).

Then raise the heat and boil briskly until the liquid has

become quite clear and nearly colorless (the digestion should take from 4 to 5 hours).

After cooling, dilute with about 200 cc. of water. Next add 50 cc. of soda solution, or sufficient to make the reaction strongly alkaline, pouring it down the side of the flask so that it does not mix at once with the acid solution. Connect the flask with the condenser, mix the contents by shaking, and distil until all ammonia has passed over into the standard acid. The first 150 cc. will generally contain all the ammonia. The operation usually requires from 40 minutes to $1\frac{1}{2}$ hours. The distillate is then titrated with standard alkali.

Previous to use, the reagents should be tested by a blank experiment with sugar, which will partly reduce any nitrates present that, otherwise, might escape notice.

**Chrome-tanned leather.**—In an ordinary analysis of chrome-tanned leather the sample is analyzed for fat, ash, and chromium.

*Fat.*—About 15 grams of the leather is weighed out and dried at a temperature of 105° C. for 2 hours. This dry sample is put in a Soxhlet extractor and extracted on the water-bath with petroleum ether for 3 hours. Distil off the ether and remove the last traces by heating in the water-oven at a temperature of 105° C. Weigh and subtract weight of the empty flask to get the weight of the fat residue.

$$\text{Percentage of fat} = \frac{\text{grams fat residue} \times 100}{\text{weight of sample}}$$

*Free sulphur.*—If there is free sulphur in the leather it can be determined by extracting a sample as described above, substituting carbon disulphide for the petroleum ether, and the residue calculated to fat and sulphur. This fat and sulphur residue is now covered with fuming nitric acid and allowed to stand over night, thus oxidizing the S to $SO_4$. Evaporate nearly to dryness in an evaporating dish, add 100 cc. water, boil and filter. Make the filtrate acid with hydrochloric acid and precipitate the sulphuric acid with barium chloride solution in the usual way.

$$\text{Percentage of S} = \frac{\text{weight } BaSO_4 \times 0.137 \times 100}{\text{weight of sample}}$$

Percentage of fat = percentage of fat + S — percentage of S.

*Ash.*—A 5-gram sample is weighed into a platinum dish and ignited, gently at first, then at high heat to constant weight.

$$\text{Percentage of ash} = \frac{\text{weight of residue} \times 100}{\text{weight of sample}}$$

*Chromium.*—The ash from the above determination is transferred to an iron crucible and intimately mixed with about five times its weight of sodium peroxide. Heat gently at first then fuse well for about 10 minutes. (*Warning: Keep face away from fusion mixture.*) Cool, place in a small casserole, cover with water and boil for about 20 minutes. Cool, filter into a 500 cc. graduated flask. Wash the paper well, allowing the washings to run into a flask. Pipette off 100 cc. into a 400 cc. beaker and add 25 cc. of hydrochloric acid, some 10 per cent potassium iodine solution and titrate with N/10 hypo in the usual way, using starch as an indicator.

$$\text{Percentage of } Cr_2O_3 = \frac{\text{cc. N/10 } Na_2S_2O_3 \times 0.00253 \times 5 \times 100}{\text{weight of sample}}$$

(Note:—In place of the sodium peroxide the ash may be heated with four times its weight of equal parts of magnesium oxide and sodium carbonate, stirring frequently with a platinum wire, or fused with about five times its weight of a mixture consisting of equal parts of sodium and potassium carbonate with a small quantity of potassium nitrate.)

If the leather contains a large amount of grease, the $Cr_2O_3$ is best calculated to the weight of leather obtained after the fat is extracted. A well-tanned chrome leather should contain at least 2.8 per cent of $Cr_2O_3$.

*Complete analysis.*—While the above determinations are usually sufficient, additional determinations are sometimes needed. The following is a scheme given by Procter for a complete analysis, using four different samples:

| | | | |
|---|---|---|---|
| *A.* | (1) Water | | (7) Tannins |
| | (2) Ash | | (8) Sugar |
| | (3) Chromium | | (9) Sulphates |
| | (4) Alumina | | (10) Chlorides |
| *B.* | (5) Fat | | (11) Barium |
| | (6) Sulphur | | (12) Lead |
| | Water solubles | *C.* | (15) Alkaline salts |
| | Water insolubles | *D.* | (16) Hide substance |

*A.* A 5-gram sample is weighed out and the following determinations made:

*Water.*—The percentage of water is determined by heating the sample to constant weight at a temperature of 105° C.

$$\text{Percentage of } H_2O = \frac{\text{loss in weight} \times 100}{5}$$

*Ash.*—The above dry sample is ignited to constant weight.

$$\text{Percentage of ash} = \frac{\text{weight of residue} \times 100}{5}$$

*Chromium and aluminum.*—The ash is fused as described under chromium determination. The fused mass is then boiled with water and filtered into a 250 cc. graduated flask. The residue on the filter-paper is well washed with hot water, and the washings run into the flask. The solution is cooled, made up to the mark, and 50 cc. pipetted off and analyzed iodometrically for chromium as described above. Calculate to $Cr_2O_3$.

For aluminum, 50 cc. of above solution is pipetted into a 250 cc. beaker, the solution made strongly acid with hydrochloric acid. Alcohol is then added and boiled to reduce the chromium to the three-bonded condition. The solution is now made alkaline with ammonium hydroxide and boiled until the odor of ammonia is very faint. Filter hot, wash well with hot water, ignite, weigh, and calculate as per cent of $Cr_2O_3 + Al_2O_3$. The percentage of $Al_2O_3$ is found by subtracting from the percentage of $Cr_2O_3 + Al_2O_3$ the percentage of $Cr_2O_3$ found iodometrically.

*B.* The 20-gram sample is weighed out, dried at 105° C., and the following determination made:

*Fat and sulphur* are determined from the above sample as previously outlined.

**Water solubles.**—The 20-gram sample from which the fat and sulphur have been extracted is heated to 105° C. for 2 hours to drive off all petroleum ether or carbon disulphide. The water solubles are dissolved from this dried sample in the manner described under vegetable-tanned leather, 500 cc. of the extract being collected. Small samples of this extract are then tested for the following:

*Tannins.*—Vegetable tannins are tested for with iron alum (getting blue or green precipitate) and if present are determined quantitatively as outlined under vegetable tannin analysis.

*Sugar.*—A small sample of water-soluble material is treated with basic lead acetate to precipitate the tannin, and the excess of lead precipitated as $PbC_2O_4$. The solution is then boiled with dilute hydrochloric acid, neutralized with sodium carbonate and boiled with Fehling solution. The presence of sugar is shown by the reduction of copper sulphate to red $Cu_2O$. If sugar is found to be present it can be determined quantitatively as outlined under vegetable-tanned leather.

*Sulphates.*—A small sample boiled with hydrochloric acid and barium chloride gives a white precipitate if sulphates are present. Determine quantitatively in the usual manner.

*Chlorides.*—A white precipitate with nitric acid and silver nitrate shows the presence of chlorides. It should be determined quantitatively in the usual manner, filtering on a Gooch, washing, drying, and weighing as AgCl.

*Barium.*—In the absence of sulphates, barium may be present. It can be tested for by adding a little sulphuric acid to a part of the solution. A white precipitate, insoluble in KOH, proves barium. A white precipitate soluble in KOH or $NH_4C_2H_3O_2$ indicates lead.

**Water insolubles:** *Sulphates.*—After extraction with hot water, the leather is soaked in 10 per cent sodium carbonate solution, ashed, and fused. The fused mass is boiled with water, filtered, washed, and the sulphates in the filtrate determined by precipitating with barium chloride.

*Barium and lead.*—The fused ash insoluble in water is

boiled with dilute hydrochloric acid and filtered. The barium and lead are precipitated from the filtrate with sulphuric acid. The $BaSO_4$ and $PbSO_4$ are weighed together. The $PbSO_4$ is then dissolved with $NH_4C_2H_3O_2$, the $BaSO_4$ weighed up, and the $PbSO_4$ obtained by difference.

*C. Alkaline salts.*—Fifteen grams of leather is extracted with carbon disulphide, and the excess driven off. It is then covered with 100 cc. of fuming nitric acid and allowed to stand over night. It is finally evaporated to dryness, dissolved in hot water, filtered, and made up to 250 cc. From this solution total soluble sulphates and alkaline sulphates can be determined.

(*a*) *Total soluble sulphates.*—100 cc. is pipetted off, the solution acidified with hydrochloric acid, and the sulphates precipitated with barium chloride in the usual manner.

(*b*) *Alkaline sulphates.*—100 cc. is pipetted off, evaporated to dryness, and ignited to remove organic matter. The residue is boiled with hydrochloric acid, evaporated to a small volume and traces of chromium removed by boiling with ammonia. Filter, add a few drops of concentrated sulphuric acid to the filtrate, evaporate, ignite at not too high a temperature, and weigh as alkaline sulphates.

*D. Hide substance.*—This is determined by the Kjeldahl method, as outlined under vegetable-tanned leather.

## PROVISIONAL METHOD FOR THE ANALYSIS OF CHROME LEATHER

*Chrome determination.*—(a) Ash 3 grams of leather. Mix the ash well with 4 grams of a mixture of equal parts of sodium carbonate, potassium carbonate, and powdered borax glass and fuse for 30 minutes. Dissolve the cooled fusion in hot water with enough hydrochloric acid to make the solution acid. Filter, and if there is any residue on the paper, ash it and treat the ash with 1 gram of the fusion mixture in the same manner as is the original ash, adding the solution to the first, and make up to 500 cc. To 100 cc. of this solution in

an Erlenmeyer flask add 5 cc. hydrochloric acid, and determine $Cr_2O_3$ as above under the analysis of one-bath chrome liquors.

(b) If it is not desired to determine Fe or Al, the ash of 3 grams of leather may be transferred to an iron crucible, mixed with 3 grams of sodium peroxide and fused 10 minutes. Place the cooled crucible in 300 cc. water in a casserole and boil 20 minutes. Wash into a 500 cc. flask, cool, and make up to the mark. Filter through a dry filter. Place 100 cc. of filtrate in an Erlenmeyer flask, neutralize with hydrochloric acid, add 5 cc. excess and proceed as in (a).

## PROVISIONAL METHOD FOR SULPHONATED OILS

*Moisture.*—Weigh between 30 and 40 grams (depending on amount of water present) into a flask of 250 to 300 cc. capacity and add 75 cc. water-saturated xylol, prepared by heating a mixture of water and xylol with frequent shaking and subsequently removing the water in a separatory funnel. Connect to a Liebig condenser and place the flask in a bath of paraffin or a heavy lubricating oil. Distil moderately until the distillate becomes clear. Collect the distillate in a tube graduated to 1/10 cc. and wash the condenser with a stream of xylol from a wash-bottle. Place the graduated tube in hot water and when the distillate is clear, cool. The percentage of moisture is obtained by dividing the volume of water in the distillate by the weight of oil taken.

(Note:—For the graduated tube Eimer and Amend's No. 3812 is recommended.)

*Ash.*—Weigh any convenient quantity into a dish or crucible. Ignite gently, allowing the oil to burn until all carbon is consumed.

*Non-saponifiable.*—Weigh approximately 10 grams of oil into an 8-oz. Erlenmeyer flask and add 5 cc. aqueous KOH solution (50 grams KOH in water and dilute to 100 cc.), 45 cc. ethyl-alcohol, and a few glass beads. Boil one hour with reflux condenser. Add 100 cc. water and cool. Transfer to separatory funnel and shake at least three times with petrol-

eum ether (B. P. 40 to 75° C.) using 50 cc. each time. Wash ether layer at least three times with 50 cc. water containing 10 cc. ethyl-alcohol. Use alcohol to break emulsion. Evaporate ether extract in tared vessel, cool and weigh.

(Note:—If the contents of the flask bump violently during saponification add 25 cc. petroleum ether, and proceed.

*Combined $SO_3$.*—(a) Weigh approximately 4 grams into an Erlenmeyer flask and boil for 40 minutes with 30 cc. HCl (1 : 5). Shake frequently. Cool, transfer to separatory funnel, and shake out with petroleum ether. Draw off aqueous layer and wash ethereal layer with water. Combine washings with main aqueous portion and determine the sulphuric acid as barium sulphate. From the amount thus found, the quantity as determined in (b) is subtracted and the difference calculated as $SO_3$.

(b) Dissolve 4 grams in ether and shake out several times with 25 cc. of concentrated brine free from sulphates. Combine the washings, dilute, filter, and determine the sulphuric acid as barium sulphate.

*Total fatty oil.*—The total fatty oil shall be the difference between 100 per cent and the sum of moisture, ash and non-saponifiable.

(Note:—The results obtained by these methods shall be reported only to one decimal place.)

## PROVISIONAL METHOD FOR ANALYSIS OF MOELLONS

*Moisture.*—Weigh accurately 3 grams of the sample in a wide platinum dish, and heat with a low flame until the moisture is all driven off. This point can be determined by the appearance of smoke, and a slight crackling sound. Place the dish in a desiccator, cool and weigh.

*Ash.*—Ash the moellon remaining in the dish after the moisture determination in the usual manner, cool, and weigh.

*Unsaponifiable.*—Weigh accurately in a 300 cc. flask, 5 grams of the moellon, add 2.5 grams of caustic potash dissolved in a little water (or 5 cc. of a 50 per cent KOH solu-

tion), and 25 cc. of 95 per cent alcohol, boil with reflux condenser for 1 hour, shaking occasionally. Glass beads may be used to prevent bumping. Add 50 cc. of hot water, cool, transfer to a separatory funnel, and extract three times, using 40 cc. of petroleum ether for each extraction. A little alcohol may be added to break persistent emulsions. Wash the combined ether solutions three times with a moisture of 30 cc. of water and 10 cc. of alcohol, transfer to a tared dish, evaporate to dryness, cool and weigh. Excessive drying must be avoided.

*Oxidized fatty acids.*—Boil the soap solution remaining from the unsaponifiable determination until all the alcohol is expelled, then dissolve in hot water, transfer to a separatory funnel, rinse the beaker thoroughly into the funnel, bringing the volume to approximately 300 cc., and immediately add a slight excess of concentrated HCl (about 25 per cent more than sufficient to neutralize the total alkali). Rotate the contents of the flask vigorously, cool and shake out with petroleum ether. Run off the aqueous layer, and pour off the ether layer, avoiding any loss of oxidized fatty acids. Wash these acids twice with small quantities of petroleum ether and hot water; dissolve in warm 95 per cent alcohol, filter if necessary, transfer to a tared dish, and place in an ordinary evaporator and dryer for 16 hours, then cool and weigh. The entire operation should be conducted without delay.

*Free fatty acids.*—Weigh out 1 gram moellon, dissolve in mixture of 20 cc. of alcohol and 20 cc. of sulphuric ether, which has been neutralized to phenolphthalein, and titrate with N/10 NaOH, using phenolphthalein as indicator. Test for mineral acids or alkalies (by adding methyl-orange to the water emulsion of the moellon), and if present, make the necessary correction.

## PROVISIONAL METHOD FOR ANALYSIS OF HARD GREASES

*Titer test.*—Saponify 75 grams of fat in a metal dish with 60 cc. of 30 per cent sodium hydroxide (36° Bé.) and 75 cc.

of 95 per cent by volume alcohol or 120 cc. of water. Evaporate to dryness over a very low flame or over an iron or asbestos plate, stirring constantly to prevent scorching. Dissolve the dry soap in a liter of boiling water, and if alcohol has been used, boil for 40 minutes in order to remove it, adding sufficient water to replace that lost in boiling. Add 100 cc. of 30 per cent sulphuric acid (25° Bé.) to free the fatty acids and boil until they form a clear, transparent layer. Wash with boiling water until free from sulphuric acid, collect in a small beaker, and place on the steam bath until the water has settled and the fatty acids are clear; then decant into a dry beaker, filter, using hot water funnel, and dry 20 minutes at 100° C. When dried, cool the fatty acids to 15 or 20° C. above the expected titer and transfer to the titer tube, which is 25 mm. in diameter and 100 mm. in length (1 by 4 inches) and made of glass about 1 mm. thick. Place in a 16-ounce salt mouth bottle of clear glass, about 70 mm. in diameter and 150 mm. high (2.8 by 6 inches), fit it with a cork, which is perforated so as to hold the tube rigidly when in position. Suspend the thermometer, graduated to 0.10° C., so that it can be used as a stirrer, and stir the mass slowly until the mercury remains stationary for 30 seconds. Then allow the thermometer to hang quietly, with the bulb in the center of the mass, and observe the rise of the mercury. The highest point to which it rises is recorded as the titer of the fatty acids.

Test the fatty acids for complete saponification as follows:

Place 3 cc. in a test-tube and add 15 cc. of alcohol (95 per cent by volume). Bring the mixture to a boil and add an equal volume of ammonium hydroxide (0.96 sp. gr.). A clear solution should result, turbidity indicating unsaponified fat. The titer must be made at about 20° C. for all fats having a titer above 30° C., and at 10° C. below the titer for all other fats.

*Unsaponifiable.*—Same as for unsaponifiable in moellons.

*Free fatty acids.*—Same as for free fatty acids in moellons.

## PROVISIONAL METHOD FOR ANALYSIS OF LACTIC ACID

*Free sulphuric acid.*—Dissolve 50 grams of the sample in 200 cc. of alcohol, which should be neutral, and of at least 95 per cent strength. Heat to 60° C., cover, and let stand over night in a warm place. Filter off precipitated material and wash with alcohol. Evaporate off the alcohol, make up the residue to 250 cc. with water, add 5 cc. strong HCl, boil, add $BaCl_2$ and determine $BaSO_4$ in the usual way. Calculate to percentage of $H_2SO_4$ on the original sample.

*Volatile acid.*—Weigh out 1 gram of sample, make up to about 50 cc. with water, titrate with N/5 NaOH. Calculate the result to lactic acid: (1 cc. N/5 NaOH = 0.045 gram lactic acid.) On this basis, make up a solution con-

Table Showing the Relation of Amounts of Volatile Acid Found in Distillate Obtained Under Standard Conditions to the Amounts Actually Present in Distilling Flask, in Milligrams.

| One Distillation | | | | | | | |
|---|---|---|---|---|---|---|---|
| In distillate | In flask | In distillate | In flask | In distillate | In flask | In distillate | In flask |
| 1 | 0.0 | 14 | 17.5 | 27 | 37.5 | 40 | 57.9 |
| 2 | 0.0 | 15 | 19.0 | 28 | 39.0 | 41 | 59.6 |
| 3 | 0.0 | 16 | 20.5 | 29 | 40.6 | 42 | 61.3 |
| 4 | 2.0 | 17 | 22.1 | 30 | 42.1 | 43 | 62.9 |
| 5 | 3.5 | 18 | 23.6 | 31 | 43.7 | 44 | 64.6 |
| 6 | 5.1 | 19 | 25.2 | 32 | 45.2 | 45 | 66.3 |
| 7 | 6.7 | 20 | 26.7 | 33 | 46.8 | 46 | 68.0 |
| 8 | 8.2 | 21 | 28.2 | 34 | 48.3 | 47 | 69.8 |
| 9 | 9.8 | 22 | 29.8 | 35 | 49.9 | 48 | 71.5 |
| 10 | 11.3 | 23 | 31.3 | 36 | 51.5 | 49 | 73.3 |
| 11 | 12.8 | 24 | 32.9 | 37 | 53.1 | 50 | 75.0 |
| 12 | 14.4 | 25 | 34.4 | 38 | 54.7 | 51 | 76.8 |
| 13 | 15.9 | 26 | 35.9 | 39 | 56.3 | 52 | 78.5 |

**Two Distillations**

| In distillate | In flask | In distillate | In flask | In distillate | In flask | In distillate | In flask |
|---|---|---|---|---|---|---|---|
| 5 | 0.0 | 22 | 19.2 | 39 | 38.9 | 56 | 58.6 |
| 6 | 1.0 | 23 | 20.4 | 40 | 40.0 | 57 | 59.8 |
| 7 | 2.0 | 24 | 21.5 | 41 | 41.1 | 58 | 61.1 |
| 8 | 3.0 | 25 | 22.7 | 42 | 42.3 | 59 | 62.3 |
| 9 | 4.0 | 26 | 23.9 | 43 | 43.4 | 60 | 63.5 |
| 10 | 5.0 | 27 | 25.0 | 44 | 44.6 | 61 | 64.7 |
| 11 | 6.2 | 28 | 26.2 | 45 | 45.7 | 62 | 65.9 |
| 12 | 7.4 | 29 | 27.3 | 46 | 46.8 | 63 | 67.2 |
| 13 | 8.6 | 30 | 28.5 | 47 | 48.0 | 64 | 68.4 |
| 14 | 9.8 | 31 | 29.7 | 48 | 49.2 | 65 | 69.6 |
| 15 | 11.0 | 32 | 30.8 | 49 | 50.3 | 66 | 70.8 |
| 16 | 12.1 | 33 | 32.0 | 50 | 51.5 | 67 | 72.0 |
| 17 | 13.4 | 34 | 33.1 | 51 | 52.7 | 68 | 73.3 |
| 18 | 14.5 | 35 | 34.3 | 52 | 53.9 | 69 | 74.5 |
| 19 | 15.7 | 36 | 35.4 | 53 | 55.0 | 70 | 75.7 |
| 20 | 16.9 | 37 | 36.6 | 54 | 56.2 | 71 | 76.9 |
| 21 | 18.1 | 38 | 37.7 | 55 | 57.4 | 72 | 78.1 |

taining about 15 grams of acid per liter. Place 150 cc. of this dilution in a long-necked 300 cc. Kjeldahl flask, connected through a Kjeldahl bulb trap to a vertical spiral condenser, the total height from the bottom of the flask to the top of the turn connecting with the condenser being between 20 and 24 inches. Distil over 125 cc. in from 47 to 53 minutes, counting from the time the first drop falls into the receiver, which should be a graduated cylinder. Add 125 cc. of water to the residue in the flask and repeat. Titrate both distillates with N/10 NaOH and phenolphthalein and calculate results to grams of acetic acid: 1 cc. N/10 NaOH = 0.006 gram of acetic acid. From these figures for acid found in distillates find actual weight of volatile acid placed in boiling flask, by means of table, and calculate this result to percentage of volatile acid in the sample.

*Free acid and anhydride.*—Titrate 50 cc. of the dilution made up for volatile acid, in the cold, with N/5 NaOH and phenolphthalein to first full pink. Call this figure "first titration." From it subtract a number of cc. of N/5 NaOH equivalent to the sum of volatile acid and free sulphuric acid present in the 50 cc. of dilution. (If the sample contains free oxalic or hydrochloric acid, the amount must be determined by appropriate methods, and further deduction made.) Calculate the remainder to lactic acid and express it as a percentage of the sample. This is the free lactic acid. After completing the first titration, add 4 cc. excess alkali, or in the case of concentrated acids, 5 cc., and stand aside at room temperature (20—25° C.) for 15 minutes. Then add 5 cc N/5 $H_2SO_4$, boil, and titrate back with N/5 NaOH. The amount of alkali used by anhydride is now found by subtraction and calculated to lactic acid. Express this as percentage of lactic acid equivalent to anhydride present in sample.

## OFFICIAL FORM FOR REPORT ON EXTRACT ANALYSIS

*ANALYSIS*

| | |
|---|---|
| Tannin .................... | Total solids ................ |
| Non-tannins ............... | Soluble solids ............. |
| Insolubles ................ | Ash ...................... |
| Water ..................... | Specific gravity ........... |
| Total ..................... | Twaddell ................. |

Analyzed by the official method of the A.L.C.A. {SLOWLY / RAPIDLY} Cooled.

**Sulphuric acid in leather:** *Procter and Searle method.*—This method is rapid, fairly accurate, and probably more used than any other method.

A 3-gram sample of leather is soaked with 25 cc. of N/10 sodium carbonate and evaporated to dryness on a water-bath. The residue is charred, pulverized, boiled out with water, and filtered through a quantitative filter-paper. The residue is ignited, treated with 25 cc. of N/10 hydrochloric acid and added to the above filtrate. This combined solution is now

titrated with N/10 NaOH, using methyl-orange as an indicator. The amount of acid found is calculated to $H_2SO_4$.

$$\text{Percentage of } H_2SO_4 = \frac{\text{cc. N/10 NaOH} \times 0.0049 \times 100}{\text{weight of sample}}$$

*Balland and Maljean method.*—A 2-gram sample of leather is weighed out and ashed. The ash is boiled out with water, filtered, the sulphates in the filtrate determined by precipitation with $BaCl_2$ in the usual manner, and calculated to percentage of $H_2SO_4$. This represents the mineral sulphates in the sample.

A second sample is weighed out, soaked with an excess of 10 per cent $Na_2CO_3$ solution, dried, ashed, boiled with water, and the sulphates precipitated, as above. This gives a measure of the free sulphuric acid plus the mineral sulphates in the leather. Calculate the sulphates in each case. The $H_2SO_4$ in the second example minus the $H_2SO_4$ in the first sample equals free $H_2SO_4$ in leather.

*Jean's method.*—A sample of leather is extracted in Soxhlet with absolute alcohol. This dissolves the free $H_2SO_4$, but not the mineral sulphates. Sodium carbonate should be placed in the extraction flask to neutralize the $H_2SO_4$. The alcohol is distilled off, the $Na_2SO_4$ is precipitated as $BaSO_4$ and calculated to $H_2SO_4$.

**Soap analysis.**—The sample should be finely shaved and put into a well-stoppered bottle. If the sample comes in small cakes, cross sections should be taken through the middle. In any case, a sample representative of the whole should be taken.

*Water.*—Five grams of the sample are accurately weighed into a platinum dish containing a small glass rod, and heated carefully on a sand-bath. The soap should be constantly stirred with the rod to prevent burning and ensure even heating. As soon as no moisture gathers on a watch-glass placed over the dish it may be removed to a desiccator, cooled, and weighed. After re-heating, it is again weighed and the process repeated until constant weight is obtained.

*Fatty acids.*—A 5 or 10-gram sample is dissolved in hot

water and washed into a separatory funnel. The soap is decomposed with a known quantity of standard hydrochloric acid, and the fatty acids thus liberated are dissolved in petroleum ether. The mixture should be well shaken to ensure a perfect separation. The aqueous layer is drawn into a flask, and the petroleum ether layer well washed with small portions of water. The wash water is added to the drawn-off portion. The petroleum ether solution is run into a tared dish, and evaporated to dryness and then heated to constant weight at 100° C.

Weight obtained $\times$ 0.97 represents fatty anhydrides.

*Total alkali.*—The aqueous solution combined with the washings from the fatty acids is titrated with standard sodium hydroxide, using methyl-orange as indicator. The difference between the amount of acid taken to decompose the soap and the back titration with sodium hydroxide represents the total alkali, which should be calculated as $Na_2O$.

*Insoluble in alcohol.*—A 5-gram sample is dissolved in absolute alcohol. If no absolute is obtainable, 95 per cent will do. If there is much water in the soap, it must be dried before dissolving. The solution is filtered through a tared filter, the residue washed with alcohol, dried at 100° C., and weighed. This residue contains sodium carbonate, sodium silicate, and other materials, which, to be determined, must be dissolved in water and titrated with standard acid, using methyl-orange as indicator.

*Free sodium hydroxide.*—The alcohol solution of soap is titrated with N/10 acid, using phenolphthalein as indicator. The titration represents free NaOH present.

*Free oil.*—A 5-gram sample is dissolved in water and extracted in a separatory funnel with petrol. The petroleum ether extract is then washed and evaporated to constant weight in a tared dish.

**Oils.**—The following methods are taken chiefly from such standard texts as Sherman's "Organic Analysis" and Woodman's "Food Analysis."

A. **Lubricating oil.**—The color, odor, turbidity, fluores-

cence, and general appearance in the standard 4-oz. sample bottle are usually noted.

*Soap.*—When added to increase the viscosity, soap is roughly tested for by seeing whether or not the ash exceeds 0.05 per cent.

*Rosin oil.*—The presence of this oil is determined by the Liebermann-Storch reaction, as follows: 5 cc. of acetic anhydride is heated gently with 2 cc. of the oil to be tested. Cool, and add a drop or two of 1 : 1 $H_2SO_4$ to the anhydride. A temporary violet color indicates the presence of rosin or rosin oil.

*Saponifiable oil (qualitative test.)*—This is tested for as follows: 4 cc. of oil is heated for 15 minutes in a test tube, in a paraffin bath with a small piece of sodium. The appearance of froth or part gelatinization indicates the presence of saponifiable oil.

The saponification number is run if saponifiable oils are present. The saponification number in the milligrams of caustic potash of KOH required to sapohify 1 gram of the oil can be determined as follows: About 2.5 grams of oil is accurately weighed into a 300 cc. Erlenmeyer flask, and 50 cc. of alcoholic KOH solution (40 grams of KOH in 1 liter of alcohol and filtered) are added; 50 cc. of the alcoholic KOH is now placed in a second Erlenmeyer flask to be used as a blank. Both flasks are connected to a reflux condenser and boiled for a half-hour. Disconnect, cool, and titrate excess KOH with N/2 HCl, using phenolphthalein as an indicator.

$$\text{Saponification No.} = \frac{\text{cc. N/2 HCl for blank—cc. N/2 HCl for sample} \times 0.028 \times 1000}{\text{weight of sample}}$$

To prevent the alcohol from turning brown by the action of KOH it is allowed to remain in contact with the KOH for two weeks, then distilled, and the solution made up as described above.

*Unsaponifiables.*—The unsaponifiable material is determined by weighing about 3 grams of the oil into a 150 cc. Erlenmeyer

flask. To this add 25 cc. of alcoholic potash (40 grams per liter) and heat with reflux condenser for one hour. Distil off the alcohol and add about 75 cc. of water to the residue. Stir the solution well and extract in a separatory funnel with 75 cc. of petroleum ether. Allow the funnel to stand until the two solutions have completely separated. Draw off the water layer into a second separatory funnel and wash it again with petroleum ether, also wash the etheric layer again with water; repeat these washings three or four times. Then combine all the ether solutions in a weighed flask and combine all the water solutions in a beaker. Distil off all ether from the weighed flask and heat to constant weight on the water-bath, weighing as unsaponifiable matter. The soap solution in the beaker can be used for a saponified fatty-acid determination by making strongly acid with concentrated hydrochloric acid, and dissolving the precipitated fatty acids in ether, 95 per cent of the insoluble fatty acids being obtained by this means.

$$\text{Percentage of unsaponifiables} = \frac{\text{weight of unsaponifiable residue} \times 100}{3}$$

If bad emulsions are encountered in this method, the following dry soap method for unsaponifiables can be run: About 3 grams of oil is dissolved in alcohol, and saponified as above with 2 grams of $KOH$. The alcohol is distilled off and 3 grams of $NaHCO_3$ and 10 cc. of methyl-alcohol is added. The solution is well stirred and evaporated to dryness. 5 cc. of methyl-alcohol and 10 grams of pure calcium carbonate is now added, mixed, and evaporated to dryness at 110° C. Extract with petroleum ether, using a Soxhlet extractor.

*Specific gravity.*—The specific gravity of the oil is determined by use of a hydrometer, specific-gravity bottle, pyknometer or Westphal balance at 15.5° C. For liquids lighter than water the specific gravity can be changed to Bé. by use of the following formula.

$$°\text{Bé} = \frac{14°}{\text{sp. gr. } \frac{60\text{ F.}}{60\text{ F.}}} - 130.$$

The specific gravity for acids of the same series decreases with increasing molecular weight; in different series the specific gravity of corresponding acids increases with the number of double bonds and OH groups.

*Cold test.* The cold test, or the temperature at which the oil just begins to flow, is determined as follows: About 25 cc. of oil is placed in a tall cylindrical 100 cc. bottle, and a thermometer is inserted through the cork so that the bulb extends just below the surface of the oil. The bottle is now immersed in a mixture of ice and salt. At every fall of 3° C. the bottle is removed and inclined until a temperature is found where the oil "sets" or just fails to flow. This is the cold test.

*Cloud test.*—The cloud test or chilling point is the temperature at which the oil becomes turbid or cloudy.

*Viscosity.*—This is one of the most important determinations for a lubricating oil. The Engler, Saybolt, and Redwood are the viscosimeters most commonly used. The relative viscosity, or body of an oil, is the number of seconds required for a certain volume of oil to run through a certain orifice at a given temperature, as compared with some standard such as distilled water or rape oil. In using the Engler viscosimeter, 240 cc. of oil is poured into the reservoir. The cover is put on, and when the temperature is just 20° C., the plug is lifted up, and the number of seconds for 200 cc. to flow out is determined. This number, divided by the number of seconds necessary for 200 cc. of water to flow out, is the Engler viscosity number. Oil employed as a lubricant is in a sense used as a cushion, to separate the two moving surfaces and prevent friction. It should have "body" enough to stand up, to stay in place and withstand the maximum pressure that it may be subjected to. On the other hand, if an oil is used which has a greater viscosity than is needed, a serious loss in power results. Oils of the same kind having the same specific gravity and viscosity may safely be substituted for each other as lubricants.

*Total acidity.*—The acidity of a lubricating oil is important. Organic acids up to 15 per cent (calculated to oleic acid) are not especially objectionable, but mineral acids should be absent.

Seven grams of oil is weighed into a 250 cc. glass-stoppered Erlenmeyer flask, and 50 cc. of 85 per cent neutral ethyl-alcohol plus 2 drops of phenolphthalein are now added. Titrate with N/10 NaOH, shaking well after each addition.

*Mineral acids.*—About 12 grams of oil are shaken out repeatedly with hot water until all of the acid is dissolved. Combine these extracts, filter, cool, and titrate with N/10 NaOH, using methyl-orange as indicator.

*Flash-point.*—Nearly fill a small evaporating dish or crucible with the oil to be tested, and set it deep into a sand-bath. The bulb of a thermometer is immersed in the oil, and the sand-bath heated with a Bunsen flame. At every 2 degrees rise in temperature a small gas flame (such as could be obtained at the end of a blowpipe) is moved across the surface of the oil at a height of about 1/10 inch. The flash-point is the temperature at which the first flash is seen.

*Burning point.*—This test is carried out as in flash-point and is the temperature at which the liquid takes fire.

*Loss on evaporation and tendency to gum.*—About 5 grams of oil, accurately weighed on a watch-glass, is heated for about 5 hours at the maximum temperature to which the oil will be subjected in use. The loss in weight should not be more than 1 per cent, and the oil should not get gummy.

*Suspended matter.*—Any great amount of suspended matter could be detected by diluting a sample of oil with petroleum ether, when the suspended matter can easily be seen. The open cup or closed cup tests as applied by the American Society for Testing Materials may also be used for this determination.

*Anti-fluorescents.*—Three cubic centimeters of 10 per cent potassium hydroxide solution is added to 1 cc. of oil and boiled; a red color shows the presence of anti-fluorescents as nitrobenzene.

**B. Oil numbers for other than petroleum and lubricating oils:** *Iodine number.*—This number is a measure of the unsaturation of oil, of the number of double bonds. It is determined either by the method of Hubl, Wijs, or Hanus. Hubl uses a solution of iodine in alcoholic $HgCl_2$. The Wijs method uses iodine chloride in place of $I + HgCl_2$, and requires less time. The Hanus method uses iodine bromide. This method has been adopted by the Association of Official Agricultural Chemists. It is a rapid method and the solution is easily made, as follows:

(13.2 grams of iodine is dissolved in 1000 cc. of glacial acetic acid, and 3 cc. of bromine is added to the cold solution.)

*Method.*—2.5 grams are weighed into an 8 oz. glass stoppered bottle; 10 cc. of chloroform is now added to dissolve the oil and 30 cc. of Hanus solution introduced from a burette; 30 cc. of Hanus solution and 10 cc. of chloroform is measured into a second bottle and carried along as a blank. Let stand for 30 minutes. Add 10 cc. of 15 per cent KI, 100 cc. of water, and titrate the excess of iodine with N/10 $Na_2S_2O_3$.

Percentage of iodine

$$= \frac{\text{cc. N/10 iodine for blank} - \text{cc. N/10 iodine sample} \times 0.0127 \times 100}{\text{weight of sample}}$$

absorbed.

*Helmer number.*—This number is the percentage of insoluble fatty acids.

*Reichert Meissl number.*—The number of cubic centimeters of N/10 NaOH to neutralize the soluble volatile acids from 5 grams of sample.

*Maumene number.*—Rise in degrees Centigrade caused by the addition of 10 cc. of concentrated $H_2SO_4$ to 50 grams of oil. This number is dependent on the number of double bonds.

*Acetyl number.*—Number of milligrams of KOH to neutralize the acetic acid obtained by saponification of 1 gram of acetylated fat. It is dependent upon the number of OH groups in the molecule.

*Titer test.*—Temperature of solidification of the mixed fatty acids.

*Acid number.*—The number of milligrams of KOH to neutralize the free fatty acid in a one-gram sample. It is determined by dissolving 5 grams of oil in neutral alcohol, and titrating with N/10 KOH, using phenolphthalein as an indicator.

*Ester number.*—Saponification number—acid number.

*Polenske number.*—Cubic centimeters of N/10 NaOH to neutralize the insoluble volatile fatty acids, distilled from a 5-gram sample.

**Analysis of titanium-potassium oxalate** (*$TiO_2$*).—Weigh accurately 10 grams of sample, dissolve in water, and make up to mark in a 250-cc. graduated flask.

To 25 cc. of the solution add about 5 cc. of concentrated sulphuric acid and heat to 60° C. Destroy oxalic acid by adding potassium permanganate solution slowly to the hot solution until a permanent pink color results. Just enough solid sodium bisulphite is now added to destroy the excess potassium permanganate and dissolve any manganese dioxide which may be formed; ammonium hydroxide is added in slight excess. Acetic acid is added in considerable excess (about 15 cc. 1 : 3 acid), and the solution digested on the hot plate for about 20 minutes. Filter off the precipitated $TiO_2$ while the solution is hot. Wash the precipitate with hot water until free from sulphates; ignite in a weighed crucible, and weigh as $TiO_2$. This determination is accurate in the absence of iron and aluminum, the acetic acid preventing the manganese from being precipitated.

If iron and aluminum are present, the following modifications should be made. Carry out the precipitation with ammonium hydroxide and acetic acid as described above, filter and wash. Dissolve the precipitate in about 15 cc. of HCl (sp. gr. 1.12). Stir a minute in the cold, then boil two or three minutes. Any undissolved material can be dissolved by adding a few drops of concentrated $HNO_3$ and boiling. Dilute, filter, and evaporate to destroy excess of acid. Dilute

to about 20 cc., and make alkaline with an excess of NaOH (avoid too great an excess). Add 5 cc. of 10 per cent $Na_2CO_3$, boil, cool, add an equal volume of water and filter. Aluminum remains in the filtrate in the form of $NaAlO_2$, and iron and titanium become insoluble and are collected on the filter-paper as hydroxides or oxides.

*Aluminum.*—This is determined in the usual way. Make the solution acid with HCl, then faintly alkaline with $NH_4OH$, boil, filter, ignite, and weigh up $Al_2O_3$.

*Iron and titanium.*—Dissolve the iron and titanium residue obtained above in the least possible amount of HCl (1.12 sp. gr.). Add 20 cc. more HCl (1.12 sp. gr.), and transfer the cold solution to a separatory funnel. Add an equal volume of ether and shake vigorously. Allow the two layers to separate and draw them off into two separate beakers. Rinse out the funnel with a little ether. Return the aqueous layer to the funnel and treat with ether as before. Repeat this treatment until the ether layer is colorless. Iron is now in the ether layer in the form of $FeCl_3$. Combine these extractions, distil off the ether and determine iron in the usual way. The titanium is found in the water extract from which it can be precipitated as $TiO_2$ or $TiO(OH)_2$ as directed above.

*Oxalate.*—Acidify 10 cc. of the original solution with $H_2SO_4$, heat to 60° C., and titrate with N/10 $KMnO_4$ as in an ordinary permanganate titration.

$$1 \text{ cc N/10 } KMnO_4 = 0.0044 \text{ gram } C_2O_4$$

*Ash.*—One gram of sample is ignited at a low red heat in a platinum dish. After igniting, the dish is transferred to a desiccator and weighed as soon as cool. Repeat the heating to constant weight; providing other metals are absent the ash is composed of $TiO_2$ and $K_2CO_3$.

*Potassium.*—The percentages of potassium and water are usually obtained by subtracting the sum of the above percentages from 100.

The potassium may be determined as follows: A 1-gram sample is dissolved in 50 cc. of hot water. Filter, wash the

filter-paper with hot water, and reject any insoluble residue. If sulphates are present, they must be removed by precipitating with $BaCl_2$ in the usual way. The excess of barium, and any aluminum which may be present, must now be removed by making the solution alkaline with $NH_4OH$, heating, and adding ammonium carbonate solution until no further precipitation occurs. Filter, wash, and proceed with the filtrate as follows: Evaporate the solution to 20 cc. and add 10 to 15 cc. of perchloric acid. Evaporate, with stirring, in a porcelain dish, until the solution becomes syrupy. Dilute and evaporate again until dense white fumes of perchloric acid are seen. Cool, and introduce 25 cc. of 95 per cent alcohol, to which 1 cc. of perchloric acid has been added. Stir well and allow to settle. Decant the clear portion through a weighed Gooch crucible and treat twice with 25 cc. of the alcoholic wash. Throw the insoluble portion on the Gooch, wash with 25 cc. of alcohol containing two drops of perchloric acid. Then wash with 95 per cent alcohol. Cover the Gooch crucible, and dry in an oven at a temperature of about 130° C. Weigh as $KClO_4$. Report potassium as $K_2O$.

**Analysis of blood albumen.**—The sample should be finely powdered and put into a well-covered vessel.

*Water.*—Dry 2 grams of the sample in a tared dish to constant weight at 100° C. Loss in weight is the water.

*Ash.*—Ignite 2 grams of the sample at a very low temperature in a platinum dish until all the carbon is burned off. Weigh as ash.

*Insoluble matter.*—Dissolve 5 grams of the sample in water and dilute to 250 cc. Pour some of this solution into a glass, add 2 or 3 grams of kaolin, stir well and pour into a fluted filter. Collect 50 cc. of the filtrate as soon as it runs clear, and evaporate to dryness in a tared dish. Evaporate 50 cc. of the unfiltered and well-shaken solution in another dish. The difference in weight of the two residues represents the insoluble matter.

*Non-albumen.*—Dilute 50 cc. of the solution used in the above determination in water, and make slightly acid to litmus

with acetic acid. Digest on steam-bath until the albumen is all precipitated and the supernatant liquid appears clear. Wash into a 250 cc. flask, cool, make up to the mark, filter, and evaporate 50 cc. in a tared dish. The residue represents non-albumen.

**Analysis of formic acid.**—The specific gravity is taken at 60° F. with a Westphal balance.

*Total acidity.*—Between 50 and 60 grams of the sample is dissolved in water, and diluted to 1000 cc.; 25 cc. of this solution is titrated with N/10 NaOH, using phenolphthalein as indicator. The result is calculated to formic acid.

*Acetic acid.*—Add about 5 grams of yellow mercuric oxide to about 10 cc. of the solution used in the above determination. Dilute to about 150 cc. and digest on the steam-bath for about 1½ hours. Filter through a fluted filter, using kaolin if necessary to obtain a clear filtrate. If acetic acid is present, a black precipitate will form in the filtrate on the addition of ammonium sulphide.

*Mineral acids.*—The $SO_4$ and Cl ions are tested for in the regular manner.

**Analysis of egg-yolk:** *Water.*—A glass evaporating dish containing some purified quartz and a small glass rod is dried in the oven to constant weight. A sample of 5 or 6 grams is weighed from the weighing bottle and thoroughly mixed with the sand in the dish. The dish is heated in the oven at 100° C., with occasional stirring to break up any lumps formed, and dried to constant weight. The loss is calculated as water.

*Ash.*—A sample of 2 or 3 grams is ignited at a low temperature in a platinum dish until charred. The carbonaceous mass is extracted with hot water and filtered into a tared dish, then evaporated to dryness. The filtrate is ignited and the residue added to the extracted portion. The sum represents the ash.

*Fat.*—The portion used for the determination of water is removed from the dish, powdered finely in the mortar and extracted with petroleum ether in a Soxhlet extractor. The

extract is evaporated to dryness at 100° C., and weighed as fat.

*Salt.*—After removing the fat, the sample is extracted with hot water, cooled, and made up to 250 cc., and 50 cc. of this solution is then titrated with N/10 $AgNO_3$, using potassium chromate as an indicator.

*Nitrogen or albumen.*—Three or four grams of the original sample is digested with 15 cc. of concentrated $H_2SO_4$ and 10 grams of potassium sulphate until clear. The digested portion is diluted with water, connected to a condenser, an excess of sodium hydroxide is added, the ammonia distilled into 50 cc. N/10 acid, and the determination completed as previously described under the Kjeldahl method. The nitrogen multiplied by 6.33 equals albumen.

**Analysis of acetate of iron liquor.**—25 grams of the sample is weighed out and diluted to 250 cc.

*Total acidity.*—25 cc. of N/10 NaOH is added to 50 cc. of the above solution in a 250 cc. flask, the solution made up to the mark, shaken, and filtered; 50 cc. of the filtrate is titrated with N/10 $H_2SO_4$, using phenolphthalein as indicator. The result may be calculated to acetic acid.

*Iron oxide.*—50 cc. of the above solution is digested to clearness with concentrated $H_2SO_4$ in a Kjeldahl flask to destroy organic matter. The digested portion is made up to 250 cc., and 100 cc. is precipitated with ammonium hydroxide in the regular manner for the determination for $Fe_2O_3$.

*Ash.*—Ignite 1 gram of the sample in a platinum dish.

*Sulphuric acid.*—Test for $SO_4$, and if present, proceed as follows: 10 grams of the sample is made up to 250 cc.; 25 cc. of the solution is measured into a platinum dish with 25 cc. of N/10 $Na_2CO_3$, evaporated to dryness, and ignited. The residue is re-dissolved in water and titrated back with N/10 $H_2SO_4$. The titration thus obtained subtracted from 25 represents in cubic centimeters of N/10 alkali the acid present as free and combined $H_2SO_4$. The acid may also be determined gravimetrically by precipitation with $BaCl_2$. Any

$FeSO_4$ present may be calculated from these two determinations and the determination of acetic acid by distillation.

*Acetic acid.*—In the presence of mineral acids, the acetic acid should be distilled off. This is done by dissolving a few grams of the sample in water, acidifying with $H_2SO_4$, and distilling until no more acid is obtained in the distillate. This will require thorough distillation.

**Some simple chemical tests for leather makers.***—The following are a few simple tests which may be applied to several of the more common materials used in the tannery without the aid of a specially arranged laboratory or any expensive apparatus, in order to tell whether or not they are adulterated.

*Lime.*—A good quicklime should slake well when mixed with water. If, on the addition of a little hydrochloric acid, it effervesces, it points to a fair amount of chalk present; while if after this treatment with acid much is left undissolved, it would indicate an excessive quantity of sand or insoluble matter.

*Linseed meal (crushed linseed).*—Make a solution in hot water, and allow to cool. When cold, add a few drops of tincture of iodine. A blue color formed would show that the linseed had been adulterated (the blue color really indicates the presence of starch, and pure linseed contains no starch).

*Dried blood.*—If the amount of ash is determined, it should be between 4 and 5 per cent. The ash should be white, and if it is a brick-red color the admixture of iron would be indicated.

*Gum arabic.*—The likely adulterant is gum tragacanth. Dissolve some of the gum, after finely powdering, in the blue solution obtained by adding ammonia to a solution of copper sulphate. If an appreciable amount is left undissolved, tragacanth is probably present.

*Dyes.*—To determine whether a dye is just a simple one or an admixture, the following procedure should be adopted: Place a small portion of the dye on the end of a penknife,

* Jour. Amer. Leather Chemists, Dec., 1916.

and blow it onto a piece of wet white blotting paper held about a foot away. The small particles will adhere to the wet paper and dissolve in the water, showing its color. By this method one may show, for example, that a dye consists of a mixture of a blue and a red dye.

*Cod-liver oil.*—This is likely to be adulterated with mineral oil. Boil two or three drops of the oil with caustic soda which has been dissolved in methylated spirit. If after continued boiling a perceptible amount is left undissolved this would indicate admixture with mineral oil. This test is based upon the fact that, under the influence of caustic soda, cod oil is converted into soap, whereas mineral oils are not so changed.

*Glucose.*—This substance may be adulterated, and if a small piece is burnt in a tin, only a very small amount of a white ash is left. Anything over a trace would indicate adulterants.

*Salt.*—Impure salt may contain a small yet undesirable amount of iron. To test for this, make a solution of the salt in water, and add a few drops of potassium thiocyanate. A red color will develop in the presence of the iron. If this chemical is not at hand, add a few drops of potassium ferrocyanide (yellow prussiate of potash), when a blue color will indicate iron.

*Ammonium chloride (sal-ammoniac).*—This should be of a pure white color, and perfectly soluble in cold water. If a small amount is heated in a tin lid over a gas flame it will be completely volatilized, no residue being left.

*Caustic soda.*—This substance, if left exposed to the air, will absorb carbon dioxide therefrom, and so gradually "carbonate." A rough test would be to dissolve a small sample in cold water, and then add a little hydrochloric or sulphuric acid (dilute). If gas bubbles are given off, this would indicate carbonates, which should not be present in a good sampl

*Ferrous sulphate (green vitriol).*—A good sample should be of a uniform pale green color. In a moist atmosphere it is liable to undergo oxidation, in which case a brownish color

will develop. To prevent this, the material should be kept in a cool, dry place, for preference in large stone jars fitted with bungs.

*Sodium thiosulphate* (*hypo*).—It is quite unlikely that this chemical will be adulterated, but as in appearance it resembles soda it may be confused with it if, say, the labels became detached from the receptacles in which they were kept. Add a little hydrochloric acid to a solution of the substance in water. If hypo, the solution will turn yellow (owing to the fine precipitate of sulphur), and an unpleasant-smelling gas will be evolved (sulphur dioxide). If, on the other hand, the substance be soda, only bubbles of an odorless gas will be given off (carbon dioxide).

*Flour.*—Alum is sometimes added to a bad quality of flour to improve its appearance. To test for this substance, the following reagent has to be prepared: 10 cc. of 5 per cent alcoholic logwood solution mixed with 150 cc. of water, and 10 cc. of saturated ammonium carbonate solution (this reagent should be mixed just before using). Some of the flour to be tested is made into a paste with water, and then a few drops of the solution added. Alum, if present, will be indicated by the formation of a blue color after the mixture has been allowed to stand for about two hours.

The percentage of ash also affords a good method of determining the quality of a flour. High-class flour yields 0.5 per cent of ash, whereas lower qualities will give from 0.5 up to 8 per cent, according to how much bran is present. Chalk, which some years ago was used as an adulterant, can be tested for by adding dilute hydrochloric acid to some flour paste, when an effervescence will take place if chalk is present.

*Egg-yolk.*—It is difficult to suggest any simple tests for the purity of egg-yolk, a chemical analysis being essential. The following tests, however, will detect the preservative present: Ignite some of the yolk to complete ash in a porcelain basin. If a large amount of a white ash is left, salt (sodium chloride) is the preserving agent. Now add a few drops of sulphuric

acid to the ash and then some methylated spirit; warm the whole, and then ignite the spirit. In the presence of boric acid, a greenish tinge will appear around the edges of the flame.

*Ammonia or ammonium hydroxide.*—This is a solution of pure ammonia gas in water, and at its greatest strength has a specific gravity of 0.880. A higher gravity than this would indicate either a weak liquor or the addition of water. If some of the solution is boiled to dryness in a dish, no residue should be left. Sulphates, chlorides, and other impurities are deposited by this treatment.

*Borax.*—It is unlikely that this substance will appear adulterated, although it is stated that soda has been used for this purpose. This could be detected by treating some of the borax with dilute hydrochloric acid, when, if soda is present, bubbles of gas will be evolved.

*Mineral acids.*—The two acids of this class used are hydrochloric and sulphuric, and to distinguish between them the following tests may be applied: Add to the acid (previously diluted with a little distilled water) a small quantity of silver nitrate solution. If a precipitate is formed, hydrochloric acid will be indicated. Using a fresh sample of the diluted acid, repeat the above experiment, using a solution of barium chloride in place of silver nitrate. A white precipitate will show sulphuric acid. By these tests, small amounts of impurities may be detected in either acid; for example, a very slight precipitate in the case of the first test will show a trace of chloride, etc. Iron may be detected in either acid by means of potassium sulphocyanide.

*Shellac.*—The only impurity which can be identified in a simple manner is any weighting material added, such as sand, etc., which may also be present in a dirty sample. Such substances will be left behind as insoluble residue when some of the material is dissolved in hot methylated spirit or hot ammonia solution. A good sample will dissolve completely in either of these two solvents. Shellac is often adulterated with rosin, but its detection is too complicated to include in these tests.

*Soda.*—Washing soda or sodium carbonate may contain iron and salt. Take some of the sample, and dissolve it in dilute sulphuric acid; or better still, in some dilute nitric acid. Divide the solution into two parts, and to one add a few drops of silver nitrate solution, when a white curdy precipitate will show the presence of salt (if only a white cloudiness appears, a trace of salt is present). To the other half of the solution add some potassium sulphocyanide, when a blood-red coloration will indicate iron.

*Carbolic acid or phenol.*—This, sometimes used as an antiseptic, is liable to contain an undesirable amount of iron. The following method will apply: About half an ounce of the sample should be burned to ash in a porcelain dish. The operation must be performed in a place where the fumes evolved can be carried away. Then dissolve the ash in a few drops of strong nitric acid and dilute with a little water. The usual test for iron with potassium sulphocyanide may then be applied.

*Sumac.*—The purity of this material, like all other tanning materials, can only be determined by an accurate chemical examination. Iron in a metallic form may sometimes be present in an undesirable amount. This may be tested for by running a strong magnet through a sample of the sumac previously spread out in a thin layer. The particles of iron will adhere to the magnet and may be removed and further examined if necessary.

*Lactic acid.*—If this acid has been adulterated with mineral matter, a large amount of residue will be left when some of the acid is boiled to dryness in a porcelain dish. To test for iron, the residue obtained above is dissolved in a little nitric acid diluted with a small quantity of water, and a solution of potassium sulphocyanide added. If present, iron will give a deep red color.

(Note:—This test also applies to acetic or formic acid.)

*Soaps.*—These, whether hard or soft, are very liable to adulteration with various admixtures. The sample should be cut into very small pieces, and a little of it boiled in absolute alcohol (or very good re-distilled methylated spirit may be

used). Only soap will be dissolved by this treatment. What is left will be alkaline carbonate, borate, silicate, together with any "filling" material, such as starch, chalk, and, in very bad cases, even sawdust.

(Note:—It might be added that to detect iron in any material containing a large amount of organic matter, the following method may always be applied: Burn the material to an ash in a porcelain (or better still a platinum) dish, and then heat the ash and, when cool, treat with nitric acid. The addition of this acid is important, inasmuch as it converts all the iron present into the ferric condition, which is essential for the final test. Having now got the iron into solution in this form, the liquid is diluted with a little water, and then a little 10 per cent potassium sulphocyanide solution is added, when a red color shows the presence of iron. If preferred, a 10 per cent solution of potassium ferrocyanide may be used instead of the sulphocyanide. In this case, however, a deep blue color will be produced if iron be present..

*Indicators.*—By means of indicators we are able to tell whether a liquor has an acid or alkaline reaction. The following table gives the colors produced when using these various indicators:

| *Indicator* | *If acid* | *If alkaline* |
|---|---|---|
| Litmus | Red | Blue |
| Methyl-orange | Red | Yellow |
| Phenolphthalein | Colorless | Red |

# CHAPTER XXII

## DISPOSAL OF TANNERY WASTE*

Tanneries are among the largest producers of industrial organic wastes. Each day's run-off consists of many millions of gallons of liquid material teeming with bacteria and containing much organic matter, both dissolved and suspended, and of a highly putrescible nature. Up to the present time practically all tanneries have been discharging this waste into streams, lakes, or sewer systems without preliminary treatment. The situation, however, is rapidly becoming acute, inasmuch as municipalities and boards of health are beginning to prohibit by law the pollution, directly or indirectly, of natural waters by industrial wastes. Where tanneries discharge their waste into local sewer systems authorities are at least insisting that suspended matter be excluded so that the sewers shall not become clogged. Where cities are treating as well as collecting their sewage and industrial waste, they are stipulating that all materials harmful or burdensome to the disposal plant processes shall be excluded, or reduced by dilution to such a degree that the waste can be successfully and economically treated. In fact, the policy now followed in some localities is to insist that no industrial effluent stronger than the average sanitary sewage be permitted to enter the local sewer system. Thus it is readily seen that the problem of disposing of tannery waste, especially where the tanner is compelled to treat his own material, is fast becoming important and serious.

### *Classification and Nature of Tannery Wastes.*

1. Soak liquors—containing blood, manure, hair, etc.
2. Lime liquors—containing lime and magnesia, calcium carbonate, hair, and dissolved hide substance.

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*The material contained in this chapter was furnished by Victor H. Kadish of Milwaukee, Wisconsin.

3. Bate liquors—containing bacteria, enzymes, hide substance, etc.

4. Pickle liquors—containing salt and acid in solution; and calcium sulphate in suspension.

5. Chrome tanning liquors—containing salts in solution; chromium compounds in solution or suspension.

6. Vegetable tanning liquors—containing tannins, "reds," coloring matter, etc.

7. Dye liquors—consisting of solutions of weak dyestuffs.

8. Fat-liquors—containing small quantities of oils and fats.

9. Wash waters—in large volumes containing undissolved or suspended solids which, when removed, leave practically pure water.

10. Condenser water.

*Plain sedimentation.*—This is the simplest and most common method now used. The sewage flows continuously at a low velocity through a settling-tank or basin, properly baffled, with the consequent settling out of a considerable percentage of the material in suspension. The supernatant liquor is drawn off at intervals, and the accumulated sludge is removed from the bottom of the tank. While the plant cost is low and operating charges are small, there are many disadvantages in this method, a few being the large floor area required, a serious objection in many cases; instability of the effluent with very little if any reduction in the number of bacteria; difficulty in removal and disposal of the sludge which is very offensive in odor and has little value as a fertilizer.

*Mechanical sedimentation.*—This is usually carried out in a circular tank with sloping bottom by means of slowly rotating arms which tend to scrub the solids towards the bottom of the sedimentation tank where they can be withdrawn by means of a pump or syphon. The sludge as withdrawn is in the liquid condition, containing about 95 per cent water, which necessitates de-watering before it can be disposed of. This method increases the rate of settling of the solids and provides a cleaner-cut handling of the sludge, but the same ob-

jections, nevertheless, maintain as above, only to a lesser degree.

With either method further treatment of the effluent is necessary if it is to be rendered relatively stable and low in bacteria. This can be accomplished by means of coarse stone trickling filters, which again occupy much space, or the effluent may be disinfected by means of liquid chlorine which largely reduces the number of bacteria when sufficient chlorine is used.

*Activated sludge process.*—This is a recently developed rapid aeration process which produces a remarkably pure effluent when applied to sanitary sewage. The raw sewage flows through rectangular tanks fitted with "filtros" plates in the bottom through which finely divided compressed air is diffused, thereby agitating the sewage violently. About 20 per cent by volume of the thickened so-called activated sludge is mixed with the incoming raw sewage as it enters the aeration tank. This combination of air and activated sludge precipitates a large portion of the organic matter in the form of a light, fluffy, brown-colored mass which is separated from the clear, purified liquor in a settling tank by means of a Dorr thickener. That portion of the sludge withdrawn from the settling tank and not returned to the aerating system must be de-watered by pressing or otherwise. This is no small problem when the nature of the material and its 98 per cent moisture content is considered. The process as a whole is delicate of control and costly, and while in its present stage of development looks promising for large municipal sewage disposal works, is hardly feasible on the small scale of tannery operation.

*Other methods of treatment.*—Heretofore, in the relatively few installations for tannery waste disposal, it has been the practice to collect the entire flow of the tannery and treat it at the disposal plant, disregarding the fact that fully 80 per cent of the volume is practically clean water. Handling large volumes means increased costs, necessity for large ground areas—frequently not available—and generally is a

heavy financial burden to the tanner, without adequate return. Advantage should be taken of this large volume of almost clean water by laying out a dual sewer system, one for the collection of foul and polluted waste, the other for the much larger volume of wash and condenser water. The latter can be merely passed through a suitable screen to remove the coarse solids in suspension such as hair, bits of flesh, tanned shavings, etc., after which the clear effluent can be conducted away from the tannery. The second and smaller system should of course collect all of the polluted waste for subsequent treatment. With a greatly reduced volume to be treated, and richer in solids as well, treatment in a mechanical sedimentation tank is feasible and economical. If, however, the required ground area is not available, the use of a recently perfected, continuously operating centrifugal machine, the so-called "ter meer," made in Germany, is suggested. This machine, occupying only a few square feet of floor space, will "scrub out" 95 per cent of the suspended matter in the form of 80 per cent moisture sludge-cake, discharged automatically, and deliver at the same time a clear effluent. No further treatment should be necessary where the tannery waste is being run into a municipal sewer system. Where it is being discharged into a potential water supply, final treatment of the effluent from settling tank or centrifuge with liquid chlorine is suggested.

Another recent discovery may change the recovery of tannery waste from the debit to the credit side: By using the so-called sulphide process for de-hairing, whereby the hair is completely dissolved, it is now commercially profitable to recover this waste sulphide liquor as fertilizer and at the same time remove from tannery waste a large percentage of the most obnoxious material. When spent sulphide liquors are rendered slightly acid, the dissolved hair (proteid colloids) is immediately precipitated in the form of a spongy, porous mass from which the water is readily expressed. This can be accomplished by means of a continuously operating process which runs itself automatically, consisting of very simple

equipment and requiring little labor. The resulting fertilizer material is uniform in composition and averages 13 per cent ammonia on a 10 per cent moisture basis, with 97 per cent of the ammonia available. This material ranks with the best grade of packer tankage, and should always command a ready market. At present fertilizer prices the manufacturing profit amounts approximately to 100 per cent. An interesting side-light in this connection is that the process provides for the recovery of a considerable portion of the original sodium sulphide used, which, together with the fertilizer produced, makes the sulphide de-hairing process much cheaper per unit of leather than the liming process.

By segregating tannery waste liquors into two classes as indicated, and by adopting the sulphide process with recovery of the spent sulphide waste as a valuable nitrogenous fertilizer material, the tanner can clean up his back yard and make a profit at the same time.

# CHAPTER XXIII

## USEFUL DATA

**Thermometer conversions.**—To convert degrees Centigrade into Fahrenheit (above freezing) multiply by 9, divide the product by 5 and add 32 to the quotient.

To convert Fahrenheit (above freezing) into Centigrade, subtract 32, multiply the remainder by 5 and divide the product by 9.

To convert Réaumur into Fahrenheit, multiply by 9, divide the product by 4 and add 32 to the quotient.

To convert Fahrenheit into Réaumur, subtract 32, multiply the remainder by 4 and divide the product by 9.

**Boiling and Freezing Points of Thermometers**

| | Boiling Point | Freezing Point |
|---|---|---|
| Fahrenheit | 212° | 32° |
| Centigrade | 100° | 0° |
| Réaumur | 80° | 0° |

### FORMULA FOR CALCULATING THE WEIGHT OF PIPES

$$W = k(D^2 - d^2)$$

W = weight of 1 lineal foot in lbs.
D = outside diameter in inches.
d = inside diameter in inches.
k = a coefficient, being
0.85 for aluminum.
2.43 for zinc.
2.45 for cast iron.
2.49 for tin.
2.64 for wrought iron.
2.82 for brass.
3.03 for copper.
3.86 for lead.

**Comparisons of Thermometers**

| Fahrenheit | Centigrade | Réaumur | Fahrenheit | Centigrade | Réaumur |
|---|---|---|---|---|---|
| 212 | 100. | 80. | 142 | 61.1 | 48.9 |
| 210 | 98.9 | 79.1 | 140 | 60. | 48. |
| 208 | 97.8 | 78.2 | 138 | 58.9 | 47.1 |
| 206 | 96.7 | 77.3 | 136 | 57.8 | 46.2 |
| 204 | 95.6 | 76.4 | 134 | 56.7 | 45.3 |
| 202 | 94.4 | 75.6 | 132 | 55.6 | 44.4 |
| 200 | 93.3 | 74.7 | 130 | 54.4 | 43.6 |
| 198 | 92.2 | 73.8 | 128 | 53.3 | 42.7 |
| 196 | 91.1 | 72.9 | 126 | 52.2 | 41.8 |
| 194 | 90. | 72. | 124 | 51.1 | 40.9 |
| 192 | 88.9 | 71.1 | 122 | 50. | 40. |
| 190 | 87.8 | 70.2 | 120 | 48.9 | 39.1 |
| 188 | 86.7 | 69.3 | 118 | 47.8 | 38.2 |
| 186 | 85.6 | 68.4 | 116 | 46.7 | 37.3 |
| 184 | 84.4 | 67.6 | 114 | 45.6 | 36.4 |
| 182 | 83.3 | 66.7 | 112 | 44.4 | 35.6 |
| 180 | 82.2 | 65.8 | 110 | 43.3 | 34.7 |
| 178 | 81.1 | 64.9 | 108 | 42.2 | 33.8 |
| 176 | 80. | 64. | 106 | 41.1 | 32.9 |
| 174 | 78.9 | 63.1 | 104 | 48. | 32. |
| 172 | 77.8 | 62.2 | 102 | 38.9 | 31.1 |
| 170 | 76.7 | 61.3 | 100 | 37.8 | 30.2 |
| 168 | 75.6 | 60.4 | 98 | 36.7 | 29.3 |
| 166 | 74.4 | 59.6 | 96 | 35.5 | 28.4 |
| 164 | 73.3 | 58.7 | 94 | 34.4 | 27.6 |
| 162 | 72.2 | 57.8 | 92 | 33.3 | 26.7 |
| 160 | 71.1 | 56.9 | 90 | 32.2 | 25.8 |
| 158 | 70. | 56. | 88 | 31.1 | 24.9 |
| 156 | 68.9 | 55.1 | 86 | 30. | 24. |
| 154 | 67.8 | 54.2 | 84 | 28.9 | 23.1 |
| 152 | 66.7 | 53.3 | 82 | 27.8 | 22.2 |
| 150 | 65.6 | 52.4 | 80 | 26.7 | 21.3 |
| 148 | 64.4 | 51.6 | 78 | 25.6 | 20.4 |
| 146 | 63.3 | 50.7 | 76 | 24.4 | 19.6 |
| 144 | 62.2 | 49.8 | 74 | 23.3 | 18.7 |

Comparison of thermometers (concluded)

| Fahrenheit | Centigrade | Réaumur | Fahrenheit | Centigrade | Réaumur |
|---|---|---|---|---|---|
| 72 | 22.2 | 17.8 | 6 | —14.4 | —11.6 |
| 70 | 21.1 | 16.9 | 4 | —15.6 | —12.4 |
| 68 | 20. | 15. | 2 | —16.7 | —13.3 |
| 66 | 18.9 | 15.1 | 0 | —17.8 | —14.2 |
| 64 | 17.8 | 14.2 | —2 | —18.9 | —15.1 |
| 62 | 16.7 | 13.3 | —4 | —20. | —16. |
| 60 | 15.6 | 12.4 | —6 | —21.1 | —16.9 |
| 58 | 14.4 | 11.6 | —8 | —22.2 | —17.8 |
| 56 | 13.3 | 10.7 | —10 | —23.3 | —18.7 |
| 54 | 12.2 | 9.8 | —12 | —24.4 | —19.6 |
| 52 | 11.1 | 8.9 | —14 | —25.6 | —20.4 |
| 50 | 10. | 8. | —16 | —26.7 | —21.3 |
| 48 | 8.9 | 7.1 | —18 | —27.8 | —22.2 |
| 46 | 7.8 | 6.2 | —20 | —28.9 | —23.1 |
| 44 | 6.7 | 5.3 | —22 | —30. | —24. |
| 42 | 5.6 | 4.4 | —24 | —31.1 | —24.9 |
| 40 | 4.4 | 3.6 | —26 | —32.2 | —25.8 |
| 38 | 3.3 | 2.7 | —28 | —33.3 | —26.7 |
| 36 | 2.2 | 1.8 | —30 | —34.4 | —27.6 |
| 34 | 1.1 | 0.9 | —32 | —35.6 | —28.4 |
| 32 | 0. | 0. | —34 | —36.7 | —29.3 |
| 30 | —1.1 | —0.9 | —36 | —37.8 | —30.2 |
| 28 | —2.1 | —1.8 | —38 | —38.9 | —31.1 |
| 26 | —3.3 | —2.7 | —40 | —40. | —32. |
| 24 | —4.4 | —3.6 | —42 | —41.1 | —32.9 |
| 22 | —5.6 | —4.4 | —44 | —41.2 | —33.3 |
| 20 | —6.7 | —5.3 | —46 | —43.3 | —34.7 |
| 18 | —7.8 | —6.2 | —48 | —44.4 | —35.6 |
| 16 | —8.9 | —7.1 | —50 | —45.6 | —36.4 |
| 14 | —10. | —8. | —52 | —46.7 | —37.3 |
| 12 | —11.1 | —8.9 | —54 | —47.8 | —38.2 |
| 10 | —12.2 | —9.8 | —56 | —48.9 | —39.1 |
| 8 | —13.3 | —10.7 | | | |

Specific gravity, degrees Twaddell, barkometer, and Baumé

| Specific Gravity | Twaddell | Barko-meter | Baumé | Specific Gravity | Twaddell | Barko-meter | Baumé |
|---|---|---|---|---|---|---|---|
| 1.000 | 0 | 0 | 0 | 1.205 | 41 | 205 | 24.5 |
| 1.005 | 1 | 5 | 0.7 | 1.210 | 42 | 210 | 25.0 |
| 1.010 | 2 | 10 | 1.4 | 1.215 | 43 | 215 | 25.5 |
| 1.015 | 3 | 15 | 2.1 | 1.220 | 44 | 220 | 26.0 |
| 1.020 | 4 | 20 | 2.7 | 1.225 | 45 | 225 | 26.4 |
| 1.025 | 5 | 25 | 3.4 | 1.230 | 46 | 230 | 26.9 |
| 1.030 | 6 | 30 | 4.1 | 1.235 | 47 | 235 | 27.4 |
| 1.035 | 7 | 35 | 4.7 | 1.240 | 48 | 240 | 27.9 |
| 1.040 | 8 | 40 | 5.4 | 1.245 | 49 | 245 | 28.4 |
| 1.045 | 9 | 45 | 6.0 | 1.250 | 50 | 250 | 28.8 |
| 1.050 | 10 | 50 | 6.7 | 1.255 | 51 | 255 | 29.3 |
| 1.055 | 11 | 55 | 7.4 | 1.260 | 52 | 260 | 29.7 |
| 1.060 | 12 | 60 | 8.0 | 1.265 | 53 | 265 | 30.2 |
| 1.065 | 13 | 65 | 8.7 | 1.270 | 54 | 270 | 30.6 |
| 1.070 | 14 | 70 | 9.4 | 1.275 | 55 | 275 | 31.1 |
| 1.075 | 15 | 75 | 10.0 | 1.280 | 56 | 280 | 31.5 |
| 1.080 | 16 | 80 | 10.6 | 1.285 | 57 | 285 | 32.0 |
| 1.085 | 17 | 85 | 11.2 | 1.290 | 58 | 290 | 32.4 |
| 1.090 | 18 | 90 | 11.9 | 1.295 | 59 | 295 | 32.8 |
| 1.095 | 19 | 95 | 12.4 | 1.300 | 60 | 300 | 33.3 |
| 1.100 | 20 | 100 | 13.0 | 1.305 | 61 | 305 | 33.7 |
| 1.105 | 21 | 105 | 13.6 | 1.310 | 62 | 310 | 34.2 |
| 1.110 | 22 | 110 | 14.2 | 1.315 | 63 | 315 | 34.6 |
| 1.115 | 23 | 115 | 14.9 | 1.320 | 64 | 320 | 35.0 |
| 1.120 | 24 | 120 | 15.4 | 1.325 | 65 | 325 | 35.4 |
| 1.125 | 25 | 125 | 16.0 | 1.330 | 66 | 330 | 35.8 |
| 1.130 | 26 | 130 | 16.5 | 1.335 | 67 | 335 | 36.2 |
| 1.135 | 27 | 135 | 17.1 | 1.340 | 68 | 340 | 36.6 |
| 1.140 | 28 | 140 | 17.7 | 1.345 | 69 | 345 | 37.0 |
| 1.145 | 29 | 145 | 18.3 | 1.350 | 70 | 350 | 37.4 |
| 1.150 | 30 | 150 | 18.8 | 1.355 | 71 | 355 | 37.8 |
| 1.155 | 31 | 155 | 19.3 | 1.360 | 72 | 360 | 38.2 |
| 1.160 | 32 | 160 | 19.8 | 1.365 | 73 | 365 | 38.6 |
| 1.165 | 33 | 165 | 20.3 | 1.370 | 74 | 370 | 39.0 |
| 1.170 | 34 | 170 | 20.9 | 1.375 | 75 | 375 | 39.4 |
| 1.175 | 35 | 175 | 21.4 | 1.380 | 76 | 380 | 39.8 |
| 1.180 | 36 | 180 | 22.0 | 1.385 | 77 | 385 | 40.1 |
| 1.185 | 37 | 185 | 22.5 | 1.390 | 78 | 390 | 40.5 |
| 1.190 | 38 | 190 | 23.0 | 1.395 | 79 | 395 | 40.8 |
| 1.195 | 39 | 195 | 23.5 | 1.400 | 80 | 400 | 41.2 |
| 1.200 | 40 | 200 | 24.0 | | | | |

### Weight and specific gravity of liquids

*Water.*—The weight of fresh water is, in practise, usually assumed at 62½ pounds per cubic foot, but 62¼ would be more nearly correct at ordinary temperatures, about 60° F. A pound of water is equal to 27.759 cubic inches.

| | Specific Gravity | Weight in Pounds per Cubic Inch | Weight in Pounds per Gallon |
|---|---|---|---|
| Water, distilled, 60° F...... | 1.000 | 0.036 | 8.33 |
| Water, sea................ | 1.030 | 0.037 | 8.55 |
| Acid, acetic.............. | 1.062 | 0.038 | 8.78 |
| Acid, nitric............... | 1.217 | 0.044 | 10.16 |
| Acid, sulphuric............ | 1.841 | 0.067 | 15.48 |
| Acid, muriatic (hydrochloric) | 1.200 | 0.043 | 9.93 |
| Alcohol, pure.............. | 0.792 | 0.029 | 6.70 |
| Alcohol, proof............. | 0.916 | 0.033 | 7.62 |
| Naphtha .................. | 0.848 | 0.031 | 7.00 |
| Petroleum ................ | 0.878 | 0.032 | 7.39 |

## WEIGHTS AND MEASURES

### Troy weight

24 grains.......................................1 pennyweight

20 pennyweights......1 ounce 12 ounces ..........1 pound

Used for weighing gold, silver and jewels.

### Apothecaries' weight

20 grains............1 scruple 8 drams............ .1 ounce

3 scruples............1 dram 12 ounces............1 pound

Ounce and pound are the same as in Troy weight.

### Avoirdupois weight

27 11/32 grains........1 dram 4 quarters....1 hundredweight

16 drams.............1 ounce 2,000 pounds......1 short ton

16 ounces............1 pound 2,240 pounds.......1 long ton

25 pounds...........1 quarter 2,204 pounds ....1 metric ton

### Dry measure

2 pints...............1 quart 4 pecks..............1 bushel

8 quarts...............1 peck 36 bushels.........1 chaldron

### Liquid measure

| | | | |
|---|---|---|---|
| 4 gills | 1 pint | 41½ gallons | 1 barrel |
| 2 pints | 1 quart | 2 barrels | 1 hogshead |
| 4 quarts | 1 gallon | 2 hogsheads | 1 pipe |

### Long measure

| | | | |
|---|---|---|---|
| 12 inches | 1 foot | 40 rods | 1 furlong |
| 3 feet | 1 yard | 8 furlongs | 1 mile |
| 5½ yards | 1 rod | 3 miles | 1 league |

### Cloth measure

| | | | |
|---|---|---|---|
| 2¼ inches | 1 nail | 4 quarters | 1 yard |
| 4 nails | 1 quarter | | |

### Square measure

| | | | |
|---|---|---|---|
| 144 square inches | 1 square foot | 40 square rods | 1 rood |
| 9 square feet | 1 square yard | 4 roods | 1 acre |
| 30¼ square yards | 1 square rod | 640 acres | 1 square mile |

### Surveyor's measure

| | | | |
|---|---|---|---|
| 7.92 inches | | | 1 link |
| 25 links | 1 rod | 4 rods | 1 chain |
| 10 square chains or 160 square rods | | | 1 acre |
| 640 acres | | | 1 square mile |
| 36 square miles (6 miles square) | | | 1 township |

### Cubic measure

| | | | |
|---|---|---|---|
| 1,728 cubic inches | 1 cubic foot | 128 cubic feet | 1 cord (wood) |
| 27 cubic feet | 1 cubic yard | 40 cubic feet | 1 ton (shipping) |
| 2,150.42 cubic inches | | | 1 standard bushel |
| 231 cubic inches | | | 1 U. S. standard gallon |
| 1 cubic foot | | | about 4/5 of a bushel |

## METRIC EQUIVALENTS

### Linear measure

| | | | |
|---|---|---|---|
| 1 centimeter | 0.3937 inch | 1 inch | 2.54 centimeters |
| 1 decimeter | 3.937 inches | | 0.328 foot |
| 1 foot | | | 3.048 decimeters |
| 1 yard | | | 0.9144 meter |
| 1 meter | 39.37 inches | | 1.0936 yards |
| 1 dekameter | 1.9884 rods | 1 rod | 0.5029 dekameter |
| 1 kilometer | 0.62137 mile | 1 mile | 1.6093 kilometers |

### Square measure

| | |
|---|---|
| 1 square centimeter | 0.1550 square inch |
| 1 square inch | 6.452 square centimeters |
| 1 square decimeter | 0.1076 square foot |
| 1 square foot | 9.2903 square decimeters |
| 1 square meter | 1.196 square yards |
| 1 square yard | 0.8361 square meter |
| 1 hectare 2.47 acres 1 acre | 0.4047 hectare |
| 1 square kilometer | 0.386 square mile |
| 1 square mile | 2.59 square kilometers |

### Weights

| | | | |
|---|---|---|---|
| 1 gram | 0.03527 ounce | 1 ounce | 28.35 grams |
| 1 kilogram | 2.2046 pounds | 1 pound | 0.4536 kilogram |
| 1 metric ton | | | 1.1023 English tons |
| 1 English ton | | | 0.9072 metric ton |

### Volume

| | |
|---|---|
| 1 cubic centimeter | 0.061 cubic inch |
| 1 cubic inch | 16.4 cubic centimeters |
| 1 cubic meter | 35.29 cubic feet |
| 1 cubic foot | 0.028 cubic meter |
| 1 cubic meter | 1.308 cubic yards |
| 1 cubic yard | 0.765 cubic meter |

### Capacity

| | | | |
|---|---|---|---|
| 1 liter | 0.0353 cubic foot | 1 cubic foot | 28.32 liters |
| 1 liter | 0.2642 gallon, U. S. | 1 gallon | 3.785 liters |
| 1 liter | 61.023 cubic inches | 1 cubic inch | 0.0164 liter |

### Multiples for conversion of quantities

| *To convert* | *Multiply by* |
|---|---|
| Grains to grams | 0.065 |
| Ounces to grams | 28.35 |
| Pounds to grams | 453.6 |
| Pounds to kilograms | 0.45 |
| Hundredweights to kilograms | 50.8 |
| Tons to kilograms | 1016. |
| Grams to grains | 15.4 |
| Grams to ounces | 0.35 |
| Kilograms to ounces | 35.3 |
| Kilograms to pounds | 2.2 |
| Kilograms to hundredweights | 0.02 |
| Kilograms to tons | 0.001 |

**Multiples for conversion of distances**

| *To convert* | *Multiply by* |
|---|---|
| Inches to millimeters | 25.4 |
| Inches to centimeters | 2.54 |
| Feet to meters | 0.3048 |
| Yards to meters | 0.9144 |
| Yards to kilometers | 0.0009 |
| Miles to kilometers | 1.6 |
| Millimeters to inches | 0.04 |
| Centimeters to inches | 0.4 |
| Meters to feet | 3.3 |
| Meters to yards | 1.1 |
| Kilometers to yards | 1093.6 |
| Kilometers to miles | 0.62 |

**Multiples for conversion of capacities**

| *To convert* | *Multiply by* |
|---|---|
| Cubic inches to cubic centimeters | 16.39 |
| Cubic feet to cubic centimeters | 28320.00 |
| Cubic yards to cubic meters | 0.7646 |
| Fluid ounces to centiliters | 2.958 |
| Gallons to liters | 3.786 |
| Bushels to hectoliters | 0.3524 |
| Troy grains to milligrams | 64.8 |
| Troy pounds to kilos | 0.373 |
| Avoirdupois pounds to kilos | 0.4536 |
| Square feet to centimeters | 929.00 |
| Square yards to meters | 0.8361 |
| Liters to quarts, dry measure | 0.908 |
| Liters to quarts, liquid measure | 1.0567 |
| Square meters to square yards | 1.196 |
| Kiloliters to gallons | 264.17 |
| Liters to gallons | 0.22 |

## APPROXIMATE METRIC EQUIVALENTS

| | | | |
|---|---|---|---|
| 1 decimeter | 4 inches | 1 meter | 1.1 yards |
| 1 liter | 1.06 quarts liquid or 0.9 quart dry | | |
| 1 kilometer | 5/8 of a mile | 1 hektoliter | 2½ bushels |
| 1 hectare | 2½ acres | 1 kilogram | 2 1/5 pounds |
| 1 stere or cubic meter | ¼ of a cord | | |
| 1 metric ton | 2,200 pounds | | |

## CAPACITY OF VATS IN GALLONS FOR EACH INCH IN DEPTH

### Circular in form

| | |
|---|---|
| 5 feet diameter | 12.24 |
| 6 " " | 17.76 |
| 7 " " | 23.63 |
| 8 " " | 31.50 |
| 9 " " | 39.38 |
| 10 " " | 48.56 |
| 11 " " | 59.24 |
| 12 " " | 70.50 |
| 13 " " | 82.74 |
| 14 " " | 95.96 |
| 15 " " | 110.16 |

Cubic capacity of a circular vat is equal to the square of the radius multiplied by 3.1416, multiplied by the depth.

### Square in form

| | |
|---|---|
| 5 feet square | 15.75 |
| 6 " " | 22.31 |
| 7 " " | 30.19 |
| 8 " " | 40.03 |
| 9 " " | 51.19 |
| 10 " " | 62.34 |

### Sundry Calculations

1 gallon contains 231 cubic inches.

1 gallon of water weighs approximately $8\frac{1}{3}$ pounds.

$8\frac{1}{3}$ pounds multiplied by the specific gravity of a liquid equals the weight of a gallon of the liquid.

*Volume of a cube.*—Multiply a side of a cube by itself and that product again by a side. If contents in gallons is desired, multiply the contents in cubic feet by 7.4805.

*Volume of a parallelopipedon.*—Multiply length by breadth and that product again by depth.

*Volume of a cylinder.*—Multiply the square of the diameter by 0.7854, and the product by the height.

*Volume of a cone.*—Multiply the square of the diameter of the base by 0.7854, the product by the perpendicular height, and divide by 3.

*Volume of a frustum of a cone.*—Add together the square of the diameters of the greater and lesser sides and the product of the two diameters; multiply the sum by 0.7854, and the product by the height; then divide the last product by 3.

*Example.*—A tank is 5 feet across the base, 3 feet across the top, and 9 feet high; get the volume:

$$(5 \times 5) + (3 \times 3) + (5 \times 3) = 49$$
$$49 \times 0.7854 = 38.4846$$
$$\frac{38.4846 \times 9}{3} = 115.4538 \text{ cu. ft.}$$

*Volume of sphere.*—Multiply the cube of the diameter by 0.5236. This rule applies to kettles which as a rule may be considered one half of a sphere.

*Diameter and speed of pulleys.*—

$D$ and $d$ diameter of driving and driven pulleys
$R$ and $r$ number of revolutions

Then

$$D = \frac{dr}{R};\ d = \frac{DR}{r};\ R = \frac{dr}{D};\ r = \frac{DR}{d}$$

**Heat, steam, evaporation and electricity**

*Total heat of saturated steam (above 32° Fahrenheit).*—

$$H = 1150.3 + 0.3745\ (t - 212°) - 0.000550\ (t - 212°)$$

where H is the total heat in B.t.u.'s above water at 32° Fahrenheit, and $t$ is the temperature Fahrenheit.

*Latent heat of steam.*—Obtained by subtracting from the total heat at any given temperature the heat of the liquid, or total heat above 32° Fahrenheit in water of the same temperature.

Heat required to generate 1 pound of steam from water at 32° Fahrenheit is 1150.4 heat units.

The heat unit (B.t.u.), is the heat required to raise a

pound of water from 62° to 63° Fahrenheit, or 1/180 of the heat required to raise 1 pound of water from 32° to 212° Fahrenheit.

French calorie = 3.968 B.t.u.'s.

1 B.t.u. = 0.252 calorie.

1 pound calorie = 9/5 B.t.u., = 0.4536 calorie.

1 B.t.u. = 778 foot-pounds of energy.

1 foot-pound = 1/778 = 0.0012852 B.t.u.

1 horsepower = 33000 foot-pounds per minute = 2545 B.t.u. per hour.

Absolute zero is — 460° Fahrenheit.

*Evaporation in vacuum.*—Approximate working figures: 3 gallons per square foot heating surface per hour.

1 pound of coal evaporates 8½ pounds of water—single effect.

1 pound of coal evaporates 16 pounds of water—double effect.

1 pound of coal evaporates 22 pounds of water—triple effect.

1 pound of coal evaporates 28 pounds of water—quadruple effect.

1 kilowatt hour =

1.341 horsepower hours.

2,655,200 foot-pounds.

3,415 heat units.

3.52 pounds of water evaporated from and at 212° Fahrenheit.

22.77 pounds of water raised from 62° to 212° Fahrenheit.

1 horsepower hour =

0.7457 kilowatt hour.

1,980,000 foot-pounds.

2,546.5 heat units.

2.62 pounds of water evaporated from and at 212° Fahrenheit.

17.0 pounds of water raised from 62° Fahrenheit to 212° Fahrenheit.

1 kilowatt =
- 1.3410 horsepower.
- 44,254 foot-pounds per minute.
- 56.92 heat units per minute.
- 3.52 pounds of water evaporated per hour from and at 212° Fahrenheit.

1 horsepower =
- 0.7457 kilowatt.
- 33,000 foot-pounds per minute.
- 42.44 heat units per minute.
- 2.62 pounds of water evaporated per hour from and at 212° Fahrenheit.

**Boiling point of water at reduced pressure**

| Inches of Mercury | Temperature Degrees Fahrenheit | Temperature Degrees Centigrade | Inches of Mercury | Temperature Degrees Fahrenheit | Temperature Degrees Centigrade |
|---|---|---|---|---|---|
| 0 | 212 | 100 | 15 | 179 | 81.7 |
| 1 | 210 | 98.9 | 16 | 176 | 80 |
| 2 | 208 | 97.8 | 17 | 173 | 78.3 |
| 3 | 207 | 97.2 | 18 | 169 | 76.1 |
| 4 | 205 | 96.1 | 19 | 165 | 73.9 |
| 5 | 203 | 95 | 20 | 161 | 71.7 |
| 6 | 201 | 93.9 | 21 | 157 | 69.4 |
| 7 | 199 | 92.8 | 22 | 152 | 66.7 |
| 8 | 197 | 91.7 | 23 | 147 | 63.9 |
| 9 | 194 | 90 | 24 | 140 | 60 |
| 10 | 192 | 88.9 | 25 | 133 | 56.1 |
| 11 | 190 | 87.8 | 26 | 125 | 51.7 |
| 12 | 187 | 86.1 | 27 | 114 | 45.5 |
| 13 | 185 | 85 | 28 | 100 | 37.8 |
| 14 | 182 | 83.4 | 29 | 77 | 25 |

Temperature of steam at various pressures

| Pounds per Square Inch | Temperature Degrees Fahrenheit | Temperature Degrees Centigrade | Pounds per Square Inch | Temperature Degrees Fahrenheit | Temperature Degrees Centigrade |
|---|---|---|---|---|---|
| 0 | 212 | 100 | 45 | 292 | 144.4 |
| 1 | 215 | 101.6 | 50 | 298 | 147.7 |
| 2 | 219 | 103.9 | 55 | 303 | 150.5 |
| 3 | 222 | 105.6 | 60 | 307 | 152.7 |
| 4 | 224 | 106.7 | 65 | 312 | 155.5 |
| 5 | 227 | 108.4 | 70 | 316 | 157.7 |
| 6 | 230 | 110 | 75 | 320 | 160 |
| 7 | 232 | 111.1 | 80 | 324 | 162.2 |
| 8 | 235 | 112.8 | 85 | 328 | 164.4 |
| 9 | 237 | 113.9 | 90 | 331 | 166.1 |
| 10 | 239 | 115 | 95 | 335 | 168.3 |
| 11 | 242 | 116.7 | 100 | 338 | 170 |
| 12 | 244 | 117.8 | 105 | 341 | 171.6 |
| 13 | 246 | 118.9 | 110 | 344 | 173.3 |
| 14 | 248 | 120 | 115 | 347 | 175 |
| 15 | 250 | 121.1 | 120 | 350 | 176.6 |
| 16 | 252 | 122.2 | 125 | 353 | 178.3 |
| 17 | 253 | 122.7 | 130 | 356 | 180 |
| 18 | 255 | 123.8 | 135 | 358 | 181.1 |
| 19 | 257 | 125 | 140 | 361 | 182.7 |
| 20 | 259 | 126.1 | 145 | 363 | 183.8 |
| 21 | 260 | 126.6 | 150 | 366 | 185.5 |
| 22 | 262 | 127.7 | 155 | 368 | 186.6 |
| 23 | 264 | 128.8 | 160 | 371 | 188.3 |
| 24 | 265 | 129.4 | 165 | 373 | 189.4 |
| 25 | 267 | 130.5 | 170 | 375 | 190.5 |
| 26 | 268 | 131.1 | 175 | 377 | 191.6 |
| 27 | 270 | 132.2 | 180 | 379 | 192.7 |
| 28 | 271 | 132.7 | 185 | 382 | 194.4 |
| 29 | 272 | 133.3 | 190 | 384 | 195.5 |
| 30 | 274 | 134.4 | 195 | 386 | 196.7 |
| 35 | 281 | 138.3 | 200 | 388 | 197.8 |
| 40 | 286 | 141.1 | | | |

## GLOSSARY OF TERMS USED IN TANNING AND RELATED INDUSTRIES

**Acid dye.** A coal-tar color which is applied to leather without a mordant.

**Airing-off.** Slightly drying the stock after application of finish.

**Annatto.** A red dye of vegetable origin.

**Antiseptics.** Preservatives which temporarily check fermentation, such as dilute solution of formaldehyde, salt, etc.

**Arm-staking.** A mechanical process employed to soften skins.

**Bacterial action.** Effect produced through the agency of certain bacteria.

**Barkometer.** A special hydrometer used in tanneries only, one degree of which is equivalent to 1.001 specific gravity. Then 30° bk.=1.030 specific gravity.

**Basic dye.** A coal-tar color which requires the presence of tannic acid to fix it on the leather.

**Bate runs.** Skins damaged by too violent action with bacterial bates.

**Bating.** Treatment of skins with hen or pigeon manure or other bacterial agents, to neutralize lime and render them flaccid. Bating also opens the pores of the skin, and so assists subsequent treatment.

**Baumé.** An arbitrary scale for determining the density of a liquid.

**Beam.** A rounded support for holding hides or skins during unhairing or fleshing by hand.

**Beam-house.** That part of the tannery where the hides are treated previous to tanning.

**Bettered.** Strengthened.

**Bleaching.** The removal of part of the surface tan to produce a light-colored stock.

**Boarding.** Producing a false grain on leather.

**Bottoming.** Filling a leather and giving a suitable foundation for a dye.

**Buffing.** Removal of the grain or flesh of leather by mechanical means to eliminate defects or obtain a level surface.

**Butt.** The best part of the skin, or hide directly over the rump.

**Cabretta.** A cross between a goat and a sheep.

**Casein.** A product obtained from the souring of milk.

**Castor leather.** A kind of glove leather.

**Centigrade.** Boiling point of water, 100 degrees; freezing point, 0 degrees.

**Chamois.** Leather produced by incorporation of an oxidizable oil, such as cod-liver oil.

**Cod oil.** Newfoundland cod-liver oil.

**Colon.** The large gut of an animal.

**Copperas.** Iron sulphate; ferrous sulphate.

**Currying.** Introducing grease into leather and giving it any desired finish.

**Deacons.** Small calfskins.

**De-greasing.** Removal of grease either by solvents, by saponification, or by pressing.

**De-hairing.** The chemical removal of hair from hides; also a general term in removing hair.

**De-liming.** Soaking skins in a weak acid or other solution to remove lime.

**Dermiforma.** An artificial bate.

**De-tanning.** Extracting vegetable tanning materials by means of borax or soda to prepare skins for re-tanning with another agent, such as chrome.

**Depilation.** The process following the soaking of hides, such as immersing them in an infusion of lime, which loosens the hair without injuring the skin.

**Depleting action.** Any action which tends to loosen the hair and epidermis.

**Dermis.** The true skin or that part from which leather is produced.

**Direct dye.** A coal-tar color which may be applied to leather without a mordant.

**Disinfectant.** A purifier; a compound which kills both bacteria and their spores.

**Drench.** A mixture of bran and water which has been allowed to ferment, and so contains acetic and lactic acids. It neutralizes and removes lime, and has a plumping effect.

**Drum.** An apparatus in which hides or skins are tumbled to aid in tanning, coloring, fat-liquoring, and stuffing.

**Dubbin.** A mixture of oil and tallow for stuffing leather.

**Effect.** Part of a vacuum apparatus used in evaporating tanning extracts or other solutions.

**Embossing.** Producing an artificial grain on leather.

**Enzyme action.** The result of unorganized ferment.

**Epidermis.** The external layer of the skin.

**Fahrenheit.** Boiling point of water, 212 degrees; freezing point, 32 degrees.

**Fat-liquor.** An emulsion of soap and oil; a mild alkali such as borax and oil, or a sulphonated oil, in which skins are worked after tanning and washing.

**Filling leather.** Introduction of substance to give weight and body.

**Fleshing.** Removal with a knife of portions of flesh, etc., which adhere to the hide. Fleshings contain considerable fat and gelatine, which are recovered.

**Fluffing.** Producing a soft effect on grain or flesh side of leathers.

**French chalk.** Talc, or magnesium silicate.

**Frizzing.** Removing the outer grain of skins on a beam after long lime treatment—30 or 40 days.

**Furs.** Skins tanned without removal of the hair.

**Fustic.** A yellow vegetable dyestuff.

**Glassing.** Producing a bright finish on the grain by means of a glass slicker or roll.

**Grain.** That portion of the hide just under the epidermis.

**Hair-slip.** An effect produced when the grain of a pelt is partly decomposed.

**Handler.** A pit containing vegetable tanning solutions in which hides are suspended.

**Hauling.** Taking hides out of lime solution.

**Hematin.** An oxidized logwood.

**Hides (green).** Raw hides from the butcher.

**Hides (split).** A hide that is split into two layers. The grain layer is used for one purpose, while the flesh split may have another application.

**Horsing-up.** Placing the hides or skins over a horse to drain.

**Irish moss.** Kelp or seaweed extract.

**Iron in tanning operations.** No iron should come in contact with hides or solutions during vegetable tanning, as iron sulphate is formed, which stains the finished goods. Wood or brass may be used.

**Jacking.** Stretching the stock on boards or frames and holding it in position by means of tacks.

**Kid.** A small goat.

**Kip.** A pelt having a weight between calf and a light hide.

**Kiss spot.** Light-covered spots which appear on vegetable-tanned leather when two hides have touched during the early stages of tanning.

**Knee-stake.** A mechanical device used especially for softening alum-tanned glove leather.

**Lamb.** A young sheep.

**Layaways.** Pits in which heavy hides receive their first tannage.

**Logwood.** A vegetable dyestuff used for producing a black color.

**Mocha leather.** A kind of glove leather.

**Mordant.** A material used to fix a dyestuff.

**Muriatic acid.** Hydrochloric acid.

**Oropon.** A patented bate.

**Osage orange.** A yellow vegetable dyestuff.

**Paddle.** An apparatus used in bating, tanning and coloring skins.

**Patent leather.** A leather with a bright varnish finish.

**Pelts.** Skins in the hair as received by the tanner.

**Perch.** A mechanical device used for softening skins.

**Perching.** Softening and stretching leather with a moon-knife or on a staking machine.

**Pickling.** Treating de-limed, bated, or drenched stock with salt and sulphuric acid.

**Plumping.** Softening and swelling of hide fibers which contain little water. Plumping follows the removal of salt on treatment with dilute acids and alkalies.

**Plunging.** Stirring up the liquors.

**Puerine.** An artificial bate.

**Puering.** Bating, but using dog manure in place of hen manure; a term also employed when other bacterial agents are used.

**Re-staking.** Further softening of leather; usually done on the dry stock.

**Re-tan.** To tan again.

**Saddening agent.** The addition of a substance during dyeing to produce a duller shade.

**Sal-ammoniac.** Ammonium chloride.

**Sal soda.** Sodium carbonate containing 12 molecules of water of crystallization.

**Salts of tartar.** Potassium carbonate.

**Salted skins.** Those cured with salt.

**Sammie.** Half dry.

**Setting-out.** Removing excess of liquid and eliminating wrinkles.

**Shearlings.** Sheepskins which have been sheared just prior to killing of the animal.

**Side leather.** Leather made from hides that have been split into sides.

**Sig.** A seasoning made of adhesive compounds (see section on harness leather).

**Skiver.** The grain side of a split sheepskin.

**Skiving.** Removing superfluous flesh from the flesh side of the leather, or separating the grain.

**Slicking.** Setting-out the wet leather by means of a slicker.

**Slunk.** The skin from an unborn calf.

**Snuffing.** A light buffing on the grain side.

**Soaking.** Washing hides with water to remove dirt, blood, and salt, previous to liming.

**Sod oil.** A product obtained by neutralizing the washing from chamois leathers.

**Spew or spue.** A white exudation which sometimes appears on the grain of finished leather.

**Splits.** The hide from which the grain has been removed.

**Stoning.** Smoothing down leather with a stone.

**Stoning-jack.** A machine which is provided with a stone, and is used for smoothing out leathers.

**Striker.** A substance applied to leather to get the color.

**Struck through.** When the tanning agent has penetrated through the hide it is struck through.

**Sumac.** The leaf of a tree largely grown in Sicily, and containing up to 30% tannin. Prices are quoted f. o. b. Palermo, per hundredweight, Yocum's test.

**Surficial.** Pertaining to the surface of the hide or leather.

**Sweating.** A natural process of putrefaction brought about by storing hides in a warm and damp atmosphere, so that bacteria grow and loosen the hair.

**Talc.** Magnesium silicate or French chalk.

**Tan.** Any material which will prevent putrefaction of hide substance.

**Tannage.** A process of converting hide substance into leather.

**Tannate.** Such as titanium tannate, a yellowish shade, on which bottom all shades of tan, brown, green, blue, and maroon can be obtained.

**Tannic acid.** The active principle in many vegetable materials, which has the power of converting hide substance into leather.

**Tanning.** Treating prepared skins with an infusion containing tannic acid.

**Tartar emetic.** Antimony-potassium tartrate.

**Tawing.** Treating skins with compounds of aluminum.

**Toggle.** Fastening hides together by means of special hooks.

**Trimmings.** The useless parts of hides, used for glue manufacture.

**Twaddell.** An arbitrary scale for determining the density of a liquid.

**Unhairing.** De-hairing; the mechanical removal of loosened hair after the action of the depilatory.

**Wallaby.** A small animal of the kangaroo family.

**Weighting leather.** Adding some material to produce weight and fullness, sometimes termed adulterating.

**Welting.** A strong thin leather cut into strips.

**Welting-stock.** That portion of a hide not suitable for sole leather and used for making welts.

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